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THE

PLEASING PRECEPTOR;

OR

FAMILIAR INSTRUCTIONS

IN

NATURAL HISTORY AND PHYSICS,

ADAPTED TO THE

CAPACITIES OF YOUTH,

AND CALCULATED EQUALLY TO INFORM AND AMUSE
THEIR MINDS DURING THE INTERVALS OF
MORE DRY AND SEVERE STUDY:

TAKEN CHIEFLY FROM THE GERMAN

OF

GERHARD ULRICH ANTHONY VIETH,
MATHEMATICAL TEACHER AT DESSAW;

INTENDED FOR

THE USE OF SCHOOLS

AND

ILLUSTRATED WITH CUTS.

VOL. I.

Simul et jucunda et idonea dicere vitæ.
HORAT. DE ARTE POET.

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PREFACE.

Of all the ſtudies, in which the minds of youth may be employed, none, perhaps, deſerve more ſtrongly to be recommended, than thoſe of natural hiſtory and phyſics. The objects on which they are occupied being ſuch as come under the cognizance of our ſenſes, they are more eaſily comprehended by the juvenile underſtanding, than the refinements of grammar, or the abſtract ideas of moral philoſophy: at the ſame time they afford an inex-

hauſtible fund of entertainment; and their great utility to all, whatever may be their future deſtination in life, no one will diſpute.

Still this is not the whole of their recommendation. They tend in a ſuper-eminent degree, to expand and enlarge the mind, and inſpire it with the moſt exalted notions of that ineffable Firſt Cauſe, from whom all things in nature received their being, and by whom the laws, that regulate and uphold them, were ordained. Neither are they by any means unconnected with moral philoſophy; for, to the moſt valuable part of morality, practical morals, they frequently lead.

Every attempt, therefore, to diffuſe a knowledge of theſe kindred ſciences,

and facilitate their acquiſition, may reaſonably hope to be received with candour; and, if tolerably executed, may be preſumed not to have been offered to the public in vain. That theſe ſciences may be ſtudied ſyſtematically with advantage, is not diſputed: but, this is in the power of few; and many a youth, whoſe time and opportunities are unequal to ſuch an undertaking, may acquire a conſiderable portion of much uſeful knowledge, in a leſs laborious and more agreeable manner, by having his attention turned to objects about him, and being made acquainted with the nature and phyſical principles of ſuch, as may reaſonably be ſuppoſed to come in his way.

Such has been the opinion of many judicious men; and Mr. Vieth has at-

tempted to carry it into execution, as it appears to me, with confiderable fkill. Much of the inftruction he gives, much of the knowledge he conveys, will be found extremely entertaining; and the whole is divefted as far as pofsible of that dry form, from which the teaching of a fcience fyftematically is infeparable. "To explain objects," I ufe his own words, "that occur in nature and in common life, which are adapted to the comprehenfion of young perfons, in a perfpicuous manner, and fo as to render them palpable to the fenfes, was the bafis of my defign. This I have endeavoured to accomplifh in fhort detached pieces, under the form of dialogues, narrative, or letters; and, for the fake of giving variety to the entertainment, I have not confined myfelf to any fyftematic order. Hence I fhall

appear occaſionally to nave touched upon ſubjects before their natural courſe; yet the intelligent reader will eaſily perceive, that this has not been done at adventure."

To this I muſt add, however, that it is the plan of Mr. Vieth, to publiſh a ſimilar volume every half year, till ſomething very like a complete ſyſtem of phyſical ſcience is produced; ſo that a general knowledge of nature may be acquired from the work by almoſt imperceptible degrees, in a pleaſing manner, and without any arduous toil. In giving his work an engliſh dreſs, I have ſtripped it as much as poſsible of it's foreign garb; and, inſtead of a ſlaviſh adherence to the original, I have added, retrenched, or altered, as appeared to me neceſſary, to render it more com-

pletely ſuitable to the uſe of engliſh ſchools, and the inſtruction of engliſh youth. Manners and cuſtoms vary; though nature and nature's laws are every where the ſame.

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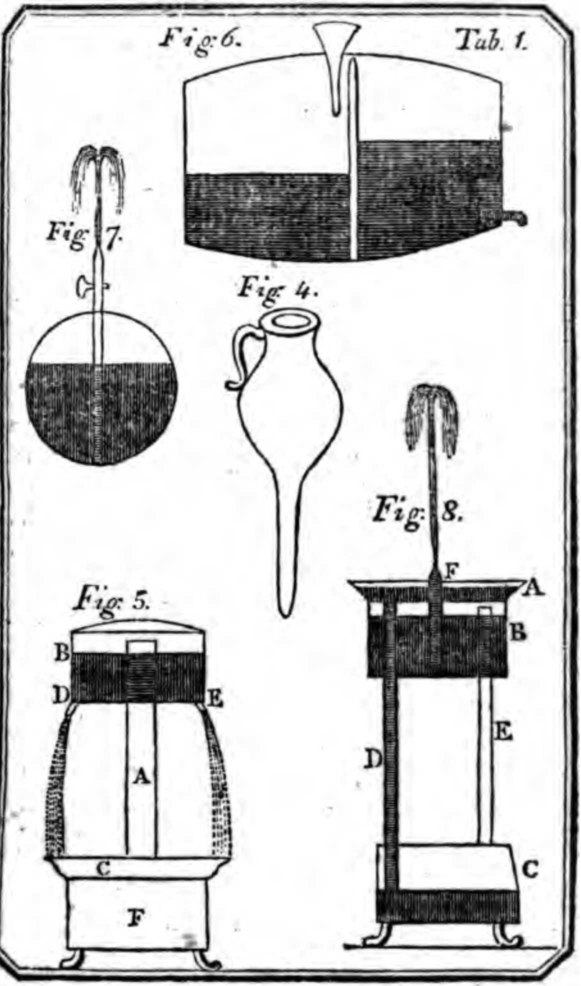

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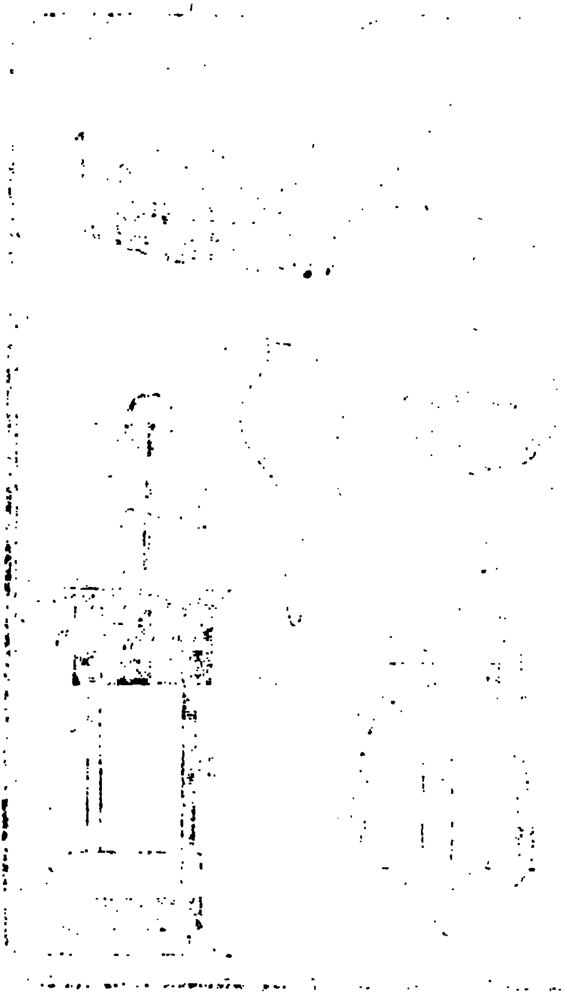

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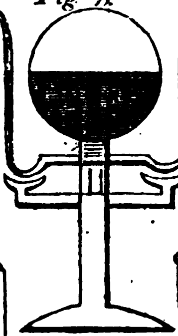

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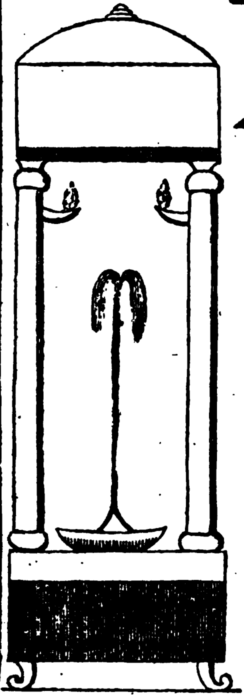

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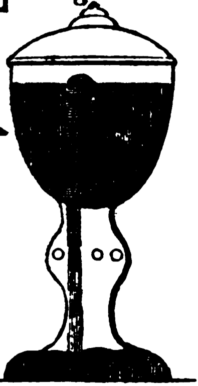

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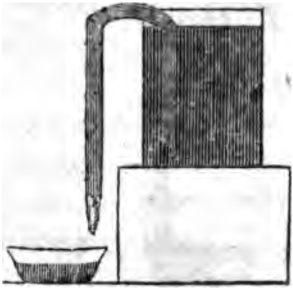


THE

PLEASING PRECEPTOR;

OR,

FAMILIAR INSTRUCTIONS, &c.

CHAP. I.

SWIMMING IRON.

"DO you think I can make iron ſwim?" ſaid William to his ſiſter Caroline.

Caroline. "No."

William. "Indeed I can."

C. "I dare not ſuppoſe you capable of aſſerting an untruth; yet I muſt doubt the fact, till I ſee it with my own eyes."

W. "Lend me a needle."

C. "What, you mean to ſtick it into a cork, and call that making iron ſwim?

W. "No, indeed: I will lay it fairly and by itſelf on the water."

Caroline took a needle, and put it into a glaſs of water. It immediately ſunk to the

bottom. "Pray now let me see you ¿
it."

William filled the glass brimful of wat
took a fine needle, which he held careful
endwise between the points of his forefing
and thumb, and laid it very gently on t
water, so that it's whole length touched t
surface at once.

W. "See there, Caroline: I told you
could make iron swim: I can make sil
swim too?"

William took a very thin silver coin, la
it flat on the surface of the water, in t
same cautious manner as he had done t
needle, and it swam likewise.

C. "How is it this happens? Iron a
silver are both heavier than water, and
thought nothing would swim, unless it w
lighter."

W. "I do not know the reason of it.
only learned the trick from one of my sch
fellows."

C. "We will ask our father: I dare
he can tell us."

William and Caroline went to their
ther.

C. "Father, William has just been m

ing a needle and a piece of money ſwim upon water: why was it they did not ſink?"

Father. "You are right, Caroline, not to ſatisfy yourſelf with the performance of the trick, without inquiring into the principles of it. You ſhould always do this, my dear children! On every occaſion examine into the grounds of things: every effect muſt have a cauſe; and though ſometimes we may not be able to diſcover the cauſe, we ſhall benefit ſomething by the very habit of reflection itſelf. To him, who does not reflect on what he ſees, a thouſand natural occurrences appear miraculous. Many feel no inclination to reflect on phenomena ſuch as this and ſeveral others, and hence ariſes baneful ſuperſtition.—But to William's tricks.—The needle and the coin do not properly ſwim; they are rather ſuſtained on the water."

C. "What am I to underſtand by that?"

F. "The particles of water have an evident coheſion together, though but a ſlight one. Now if any body, though heavier than an equal bulk of water, be not heavy enough to overcome the coheſion of all the particles that ſupport it, it will ſwim; though, if this coheſion be once broken, it will ſink to the

bottom. Look attentively at the water, where the needle lies upon it, and tell me what you obſerve."

W. "The ſurface of the water is regularly depreſſed by the needle; and forms a ſort of rim round it."

C. "I underſtand now why my attempt did not ſucceed. I did not lay the needle lightly upon the water, and all it's parts at once."

F. "You are right: the coheſion of the water in the point where the needle firſt touched it was inſtantly overcome by the weight of the needle, and ſo it was in all the other points in ſucceſſion; but if the coheſion of it in all theſe points had been to be overcome at once, the reſiſtance would have been greater than the preſſure of the weight of the needle, ſo that it would have been ſuſtained on the ſurface. You may obſerve the coheſion of water in every drop that hangs on the eaves of the houſe: it remains ſuſpended, till by the addition of freſh particles of water it acquires ſufficient weight, to overcome the coheſion where it is drawn out into a neck, when it falls to the ground."

CHAP. II.

WATER THAT DOES NOT WET.

"I will now ſhow you another experiment," ſaid Mr. Goodwyn, dropping a halfpenny into a glaſs of water. "Can either of you take this halfpenny out with your bare fingers, without wetting them?"

Neither William nor Caroline knew how it was to be accompliſhed.

F. "See, I will throw a little of this yellow powder* on the water, and when the ſurface is covered with it, you may dip your fingers into the water without wetting them."

Caroline put her fingers ſlowly into the glaſs, felt the cold water round them, and was not a little ſurpriſed, when ſhe took them out with the halfpenny, to find them dry.

F. "You want to know the reaſon of this, do you not?"

C. "I own, I do not underſtand it."

W. "I, too, ſhould like to know why it is ſo."

F. "I will tell you. When we ſay a thing dipped into water is wetted, it im-

* The ſeed of the common clubmoſs, *lycopodium clavatum*, Lin.

plies, that the particles of water adhere t
it. Now there are many bodies, to whic
water readily adheres, and this with mo
force than the particles of the water cohe
together. Such a body, when it is take
out of the water, brings out particles of tl
water adhering to it; as a piece of pap
does, or the fingers, for example. On tl
contrary, there are other bodics, to whi
the particles of water adhere lefs forcibl
than they cohere together; and as fu
bodies, when taken out of the water, ca
not bring out any particles of water wi
them, they remain dry. Such, for inftan
is a tallow-candle, or any thing of a grea
nature in general, as well as this powd
with which I have juft made the expe
ment. This powder forms a kind of fi
over the water, and adheres to the fing
like a glove; confequently, as the partic
of water cohere together more ftrongly th
they adhere to this powder, they are p
vented from coming into contact with t
finger and wetting it."

W. "I obferved Caroline's fingers look
as if they had a yellow glove on, when th
were in the water."

F. "Now let me afk you, how can a n

water in a handkerchief, without it's ing through ?"

"Perhaps by means of this powder. me try !"

iroline ftrewed fome of the feed over her kerchief, gathered it up by the edges in hand, fo as to form a bag, and poured water into it, which did not run igh. "This is very curious," exclaimhe: "I could not have thought it ole."

"Hence, my children, you may learn, we fhould not be too hafty in procing a thing impoffible, becaufe we have feen it performed. There are many s, of which you would fay it is impofthough they are perfectly natural. In very fame manner, in which you carry in this bepowdered handkerchief, quickmay be carried in a bag of linen, or of tiffany: and if you dip your fingers a veffel full of quickfilver, they will not etted, or have any of the quickfilver e to them; becaufe the cohefion of articles of quickfilver to each other is ger than their adhefion to your fingers, the tiffany."

CHAP. III.

THE PASSAGE OVER THE RIVER.

On a little excurſion on foot, that William once made with his father, they came to a river, over which there was a ferry. William and his father, however, were rowed over in a boat. Playing with a ball was a favourite amuſement of William's, and as they were paſſing over the river, he took his ball out of his pocket, and threw it up a little way, to catch it. Conſidering with himſelf, that the boat would be moving forward while the ball was aſcending and falling, he ſuppoſed it muſt be neceſſary for him, to throw it a little forwards, inſtead of toſſing it up in a perpendicular direction. It fell before him, however; and on his trying again, it did the ſame. A third time he threw it up, but perpendicularly, and caught it. "How is this?" ſaid he to his father. "I thought, if I threw it up ſtraight, as I do on ſhore, the boat would row away from under it, and it would fall into the water behind me."

"I will explain it to you by and by," anſwered his father. "At preſent look at

the ferry-boat; ſee there it goes, with a coach, and horſes, and paſſengers, ſwimming along by the rope, as if of itſelf, without the ferryman's taking any trouble with it."

William obſerved it with wonder. Caſting his eye in the mean time on the bank of the river, he ſaid haſtily to his father; "but whither is our boat going? See, father, that is the place where we ſhould land, and the boatman is rowing up yonder, a great way higher up the ſtream, and on this ſide of the river. Boatman, you are going wrong."

Boatman. "No, no, maſter; the boat is going very right."

Father. "Let the boatman take his own courſe, he knows what he is about better than you.—See, he is now rowing ſtraight acroſs the river, but the boat deſcends obliquely toward the place, where we are to land. If the boatman had begun to row ſtraight acroſs, when we ſet out, we ſhould have been drifted down much below it, ſhould we not?"

W. "Yes, I ſee we ſhould now."

They landed, and purſued their way. William expected an explanation of the paſſage over the river; for he well knew, that his

father eagerly seized every opportunity of imparting to him information respecting the things that occurred around him, if it were in his power, to give him just ideas of them; and on this occasion he was not disappointed.

"In the few minutes, that we spent in passing over the river," began his father, "you observed several things, which you never had an opportunity of seeing before. Tell me what they were."

W. "I do not understand why the ball, when I threw it straight up, did not fall behind me; or how the ferry-boat passed across the river of itself; or why the boatman first rowed us some way up the river."

F. "Very well. Attention to the object itself is the first step toward attaining a knowledge of it. All three of the phenomena you have mentioned proceed from one and the same cause, which I will take this opportunity to explain to you."

"I need not tell you, in the first place, that every motion requires a moving power. You already know, likewise, from experience, that a ball, or any other body, moves in a straight line in that direction, in which the power impels it. Thus, in playing at fives, *when you move your* hand in a straight line

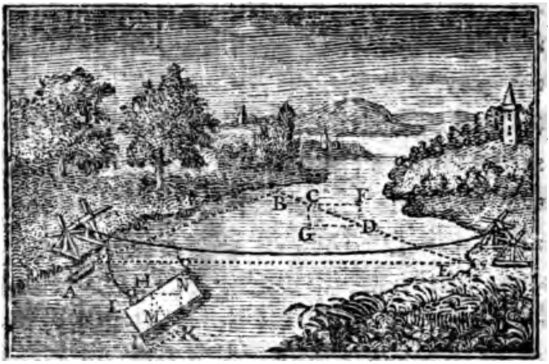
toward the ball, and ſo ſtrike it, it is impelled in that direction againſt the wall, if there be no obſtacle in the way."

W. "But, father, if I throw a ball over the wall, it does not go in a ſtraight line, but in a curve."

F. "That is very true; and the reaſon is, that the ball is not acted upon by the moving power of your hand alone, but by it's own gravity likewiſe; for gravity is nothing elſe but a power, which impels a body perpendicularly to the earth. Accordingly, we have not one power acting here, but two; and this is juſt the caſe in the three phenomena you noticed during our paſſage over the river.

"Now when a body is impelled by two powers at the ſame time, which powers have different directions, it cannot follow either of theſe directions ſimply, but muſt take a *middle courſe*, in which it obeys the impulſe of both powers at the ſame time. This you will comprehend with much more clearneſs and facility, if I explain it to you by a figure; and, as we have time enough to ſpare, we will ſit down on this riſing ground, and proceed to the inveſtigation."

William pulled out his pocket-book, which by his father's advice he always carried with him, in order to make a memorandum, or take a ſketch of any thing remarkable that occurred, and gave it to his father, who drew on one of the leaves the figure that follows:



F. "Suppoſe A to be our boat, and E the place at which we would land. We firſt rowed along the bank from A to B, our boat then came to C, to D, and ſo on, till at length it reached E.

"To underſtand why this roundabout courſe was neceſſary, we will conſider the boat as at C. Here it is impelled by two powers; the ſtream urges it in the direction C G, the oars in the direction C F. If it were impelled by the ſtream alone, in one ſecond it

would paſs from C to G; if the water were ſtill, ſo that it was impelled by the oars only, it would paſs in one ſecond from C to F; but being impelled by both powers, it paſſes in one ſecond from C to D, a middle direction between the two. The figure will ſhow you how this direction is found."

W. "I perceive by the figure, that the line C D is the diagonal of a parallelogram, of which C G and C F are the ſides."

F. "Thus to find the middle direction, which a body impelled by two powers will take, we mark the directions of the moving powers by lines, make the length of theſe lines proportional to the forces of the powers, complete the parallelogram, and the diagonal is the direction ſought. Is it not true, that the boat, when it has reached D, has expended the impulſe given it by both the moving powers?"

W. "Certainly; for it has paſſed down the ſtream as far as D, and the ſpace F D is exactly equal to C G, through which the ſtream alone would have driven it; while the ſpace G D is equal to C F, ſo that it has reached exactly the ſame diſtance from the bank, as it would have done if it had been *impelled by the oars only*."

when explaining the oblique course of our boat across the river, I perceive they would."

F. "Then we may *resolve* the impulse of the water, H I, into the two *lateral powers*, H L, and H K; but can the power H L contribute any thing to the motion of the ferry-boat?"

W. "No, since it passes along the side of the ferry-boat, and therefore cannot act upon it."

F. "But H K, which is perpendicular to the side of the ferry-boat, acts wholly upon it; and this is the advantage we derive from the *resolution of an oblique power*, namely, we obtain one power, which we may leave wholly out of consideration; and another, to which we must pay all our attention. The impulse of the water, therefore, has just the same effect in moving the boat, as the power H K would have; but can the ferry-boat move in the direction H K?"

W. "No; it can only move along the great rope from H toward E."

F. "Let us then proceed to resolve H K into two other powers, H M, and H N; will not these effect, what would have been effected by H K?

W. "No doubt they will, from what has been already ſaid."

F. "Can the ferry-boat obey the impulſe of the power H M?"

W. "No; for the great rope prevents it."

F. "The effect of H M therefore is completely counteracted by the reſiſtance of the rope. But H N remains, for the ferry-boat can move preciſely in this direction. Accordingly the impulſe of the ſtream acts juſt the ſame in moving the ferry-boat along the rope, as any power equal to H N would do, impelling the ferry-boat acroſs the river; and this, as you will readily perceive, as well from the left bank to the right, as from the right to the left *, merely by preſenting it's ſide in a different direction to the ſtream.

"It is now time for us, however, to reſume our walk, or we ſhall make our journey too late."

William would willingly have heard a little more on the ſubject; for, by reflecting on it, a few queſtions had ſuggeſted themſelves to his mind. He conſidered, when

* The right bank of a river is that, which is on the right hand of a perſon, who looks *down* the ſtream.

the ferry-boat lies with it's side parallel to the rope, the stream cannot move it; but as soon as the stream has turned the stern round a little, it begins to advance. And, if the stern were not fastened to the great rope, it would soon be turned so far round, that the flat head would become parallel to the rope, and then it would stop. Then there must be one particular direction, in which it will make the greatest progress.

His father was greatly pleased, to find he had reflected so much on the subject; but told him, that he must acquire a little more mathematical knowledge, before it could be properly explained to him. For the present, too, his father left his curiosity unsatisfied with respect to the falling of the ball, but promised to explain it to him the first opportunity.

CHAP. V.

THE TOWER.

William's curiosity was stimulated by the instruction his father had imparted to him. It gave him much pleasure, to learn the reasons of those appearances, that are of ordinary

occurrence. The greater number of mankind look upon ſuch things as common and unuſual, without thinking any farther about them, or imagining, that there is any more ſcope for thought. William's father conſidered it as an eſſential point of the ſuperiority of a well educated perſon, not to be ignorant in ſuch common things; and, in conſequence, endeavoured, as far as his buſineſs would permit him, to convey information to his children reſpecting them, whenever an opportunity offered.

He knew from experience, that inſtruction thus opportunely communicated, when occaſion led to it, when the curioſity of the pupil was excited by the object coming before his eyes, was more intereſting, uſeful, and entertaining, and both imparted and received with more pleaſure, than ſcientific and learned leſſons given in ſyſtematical order. Not that he deemed ſuch regular leſſons by any means unneceſſary; for he obſerved to his ſon William, then ten years old, " When you are a few years older, you will learn all this more regularly and fundamentally from proper books, and oral inſtruction, if at the ſame time you apply with induſtry,

and exercife your own reflection, which are the prime requifites to all learning. In the mean time, what you learn from me on our walks, or by our firefide, will be, I hope, an advantageous and pleafing initiation to you, and particularly accuftom you early to exercife your own reflection; and if at any future time we fhould live apart from each other, as well as when I am gone from you for ever, the recollection of your early years, which you fpent under the care of your parents, will be fo much the more grateful to you, and you will think of me the longer, and with the more affection."

The road our pedeftrian travellers took led them by an ancient tower. William was defirous of going up to the top of it, in order to have a more extenfive view of the country round; and, as this might be done without danger, his father readily gratified his wifh. When William had admired the profpect, he amufed himfelf with letting the loofe fragments of ftone, feveral of which lay there, fall from the top to the bottom, to fee how long they would be in falling. His father lent him his ftop-watch for the purpofe; and he found, that a ftone took as

nearly as poſſible three ſeconds in falling to the ground.

F. "Can you tell me how high this tower is, William?"

W. "How ſhould I know that, father, without a ſtring long enough to meaſure it?"

F. "Do you not think, that you may learn it's height from your preſent amuſement, letting a ſtone fall?"

W. "O, that is true. I have only to let a ſtone fall as far as it will in one ſecond, and meaſure that height, and then I ſhall know it would fall three times as far in three ſeconds."

F. "Indeed you are much miſtaken. Thus you ſee, how eaſily we may be led into an errour, when we form a judgment haſtily, and from a ſuperficial conſideration of a thing. Have you any wiſh, to underſtand the ſubject thoroughly?"

W. "Yes, certainly; for I do not like, to make miſtakes."

CHAP. VI.

HOW DOES A STONE FALL?

F. "What is the reaſon, that a ſtone, when left to itſelf, falls perpendicularly to the ground? or, if it be ſuſpended by a ſtring, ſtretches the ſtring in a perpendicular line? or, if held on the hand, preſſes upon it perpendicularly?"

W. "The gravity of the ſtone."

F. "At leaſt that is the name we give this cauſe, of which we know nothing, but that it is a power, which continually impels a body toward the Earth, as if the Earth drew the body, or attracted it toward itſelf. Nothing is more common than the action of gravitation. We daily ſee bodies fall; the effects of this attraction of the Earth for the bodies upon it are for ever exerted around us; but for this attraction, no table, no chair, no houſe, would ſtand firm; every thing would be flying about in confuſion. It is worth our while, to gain a knowledge of the laws, which regulate the action of a henomenon of ſuch perpetual occurrence."

W. "I ſhould be very glad to know them."

F. "If we conſider a portion of time ever ſo ſhort, the power of gravitation, or the attraction of bodies by the Earth, operates in it. Divide a ſecond in imagination into ten parts; in the firſt tenth the power of gravitation would impel the ſtone through a ſhort ſpace, ſay a tenth part of the length of this ſtick. Now, if the power of gravitation acted no longer, the ſtone would not on that account ſtand ſtill, but would continue on it's courſe in the ſame direction, and with the ſame velocity as before; for, *as a body at reſt cannot be ſet in motion, without ſome power acting upon it, ſo a body in motion cannot be reduced to a ſtate of reſt, without ſome power oppoſing it's motion.* This property of bodies is called *vis inertiæ*, by which nothing more muſt be underſtood, than the perſeverance of a body in the ſtate, in which it happens to be."

W. "But if I bowl a ball along the ground as hard as I can, it will at laſt ſtop."

F. "Very true; but what ſtops it? The unevenneſs of the ground, over which it rolls; the power of gravitation, which impels it

toward the Earth, and caufes it to rub againft the ground as it moves along; and the refiftance of the air, which is fo much the greater in proportion to it's velocity. Take all thefe obftacles away, and your own judgment will tell you, there is nothing, to ftop the ball. Confider how long a ball continues rolling over a plain of ice. We are digrefsing, however, from our fubject. To return to it, if a ftone received merely the firft impulfe from the power of gravitation, it would continue falling, till it came to the ground; and in each tenth part of a fecond of time, it would fall through the fame fpace, fo that in one fecond it would fall through ten fuch fpaces."

W. "That is clear."

F. "But as the power of gravitation continues to act with equal force on the body, it gives the body a frefh impulfion every inftant, fo that in the fecond tenth part of the fecond it would fall through two fuch fpaces, in the third through three, in the fourth through four, and in the laft or tenth part, confequently, through ten fuch fpaces. Have you a clear comprehenfion of this, too?"

W. "Perfectly."

F. "Juſt ſo have I heard others expreſs themſelves, and indeed perſons who might be ſuppoſed to underſtand the ſubject, as they ſcarcely paſs a day without having a gun in their hands. In you it is very excuſable. But then how is it, that, when the piece is well aimed, and properly fired, the ball ſometimes flies over the mark, not under it? and how is it, that the ſame piece, well fired, and with preciſely the ſame charge, at a certain diſtance hits the mark, at a greater diſtance ſhoots under it, and at a leſs ſhoots over it?"

W. "I do not know, but no doubt you can tell me."

F. "You muſt be aware, however, that, if the ball proceeded in a direct line to the mark, it muſt hit it at a leſs diſtance as well as at a greater."

W. "To be ſure."

F. "But it has been found by repeated experiment, that, with a good rifle-barrelled gun, and the uſual charge of powder, which is about the fifth part of the weight of the ball, if the barrel be levelled directly at the mark, the ball will paſs about a foot below it, ſuppoſing the mark to be at the diſtance

it will fall through in the second second of time?"

W. "That may be found as before. If I add 11 to 20, I shall have 31; and if I multiply 31 by 5, the sum will be 155. So that in the second second of time the stone will fall through 155 tenths of the stick, or 15 times and half it's whole length."

F. "Now take out your pocket-book, and calculate the fall for a few more seconds on the same principle."

William calculated and found

For the	3d	4th	5th	6th	7th	8th	9th	1 th
1st space	21	31	41	51	61	71	81	91
last space	30	40	50	60	70	80	90	100
added together	51	71	91	111	131	151	171	191
multiplied by	5	5	5	5	5	5	5	5
product	255	355	455	555	655	755	855	955

F. "Your last line, you know, consists of tenth parts of the standard we have assumed; now write down all the spaces, from the first second to the tenth, in whole numbers and fractions."

Accordingly William wrote

Seconds	1	2	3	4	5	6	7	8	9	10
Spaces	5½	15½	25½	35½	45½	55	65½	75½	85½	95½

edge of the breech at V, the ſight at K, the mark, or centre of the target, at Z. Now if O V K Z be in a direct line, and, as we will ſuppoſe here, in a horizontal one, the axis of the barrel will not lie horizontally, but inclining a little upwards, ſo that the ball, if it proceeded in a ſtraight direction, would arrive at L, but, being acted upon by the power of gravitation, it proceeds in the curve K S Z, and thus hits the mark. In the ſame manner, when the piece is diſcharged from P at the bird on the pole in Q, the end of the barrel is directed higher, toward R, and the ball deſcribes a curve from P to Q."

W. "I now perceive, why a gun, with a given charge, can carry true only at a certain diſtance; for if the target be nearer, as at X, the ball will be above the line of aim, O Z, when it reaches the diſtance of the target, and conſequently will paſs over the mark; and if the target be farther, as at Y, the ball will be below the line, and paſs under the mark."

F. "How then ſhould we manage, to adapt a gun to a greater diſtance, or a leſs?"

W. "For a leſs diſtance the ſight muſt be

how far a body falls in the firſt ſecond, which may be done pretty accurately by experiment; and in this way it has been found, that the ſpace a body falls through in a ſingle ſecond of time is about ſixteen feet, or ſixteen feet and an inch. Hence, if you take ſixteen feet for the ſpace paſſed through in the firſt ſecond of time, you may eaſily calculate the ſpaces for the ſucceeding ſeconds."

William wrote down the ſpaces in his pocket-book, beginning with 16, and multiplying this number according to the ſeries; firſt by three, next by five, and ſo on. Thus he obtained the following numbers in feet.

Seconds	1	2	3	4	5	6	7	8	9	10
Spaces	16	48	80	112	144	176	208	240	272	304

In doing this, he perceived, that the ſeries might eaſily be calculated, by adding at each ſecond 32 feet to the ſpace gone through in the preceding.

F. "We will now compare the whole time, and the whole ſpace of the fall together. If a ſtone in the firſt ſecond fall through a given ſpace, and in the next three times that ſpace, how far will it have fallen in the two ſeconds?"

W. "Through four times the ſpace of the *firſt ſecond.*"

CHAP. XI.

GUNPOWDER.

WITH respect to the invention and composition of gunpowder, William could only find, that a monk, of the name of Berthold Schwarz, in the fourteenth century, was said to have pounded together some saltpetre, sulphur, and charcoal; that a spark from his candle accidentally fell into the mortar; and that the mixture from this caught fire, and blew the stone, that covered the mortar, up into the air.

Father. " This was long the current opinion: but it is now known, that the invention must have been much earlier. Roger Bacon, who was born in 1214, and died in 1294, and was deemed a conjuror by the ignorant people of those days for the great superiority of his knowledge, has a much stronger claim to the invention than Schwarz; for in his works the composition of gunpowder is described, though in an enigmatical manner, no doubt from an apprehension of the mischievous purposes, to which it might

W. "If the ſtone were three ſeconds in falling to the ground, in this time it would fall through nine times ſixteen feet, or 144 feet, ſo that the tower muſt be 144 feet high."

F. "This it would be exactly, according to the laws of falling bodies, which we have diſcovered; but you muſt never forget, that theſe will only give you an approximation to the truth, for the air reſiſts the falling of bodies, and this in proportion to the velocity, with which they fall. From this circumſtance, a ſtone will be ſomewhat longer in arriving at the ground, than if it fell through a ſpace void of air. In denſe bodies, as a ball of lead, this difference is much leſs, than in ſuch as have little weight in conſiderable bulk, as a piece of light wood, a ſponge, or a hollow globe of glaſs. The laſt would be greatly retarded in it's fall."

W. "I have often remarked, that a flint ſtone falls faſter than a ball."

F. "In the air it does; yet in a place deſtitute of air both would fall with equal velocity."

W. "But how can we make a place to have no air in it?"

F. " There is a particular machine for this purpofe, called an air pump, which I fhall hereafter fhow and explain to you. In the mean time I have a queftion or two more to afk you, that relate to our prefent fubject.

" What velocity will a body acquire in a given time, fuppofing it to fall freely?

" This queftion, however, is too difficult for you to give it a direct anfwer; we will therefore divide it a little. Suppofing the fecond of time to be divided into tenth parts, as we did at firft, how many fuch fpaces, as the falling body paffed through in the firft tenth part, does it pafs through in the laft tenth part of the firft fecond?"

W. " Ten."

F. " And if it continued to move with the fame velocity, receiving no frefh impulfe from the power of gravitation, how many would it pafs through in the next fecond?"

W. " Ten times ten, or a hundred."

F. " Now in the firft fecond of time, you remember, according to our calculation, it fell through 55; fo that if we had taken our divifions of the fecond fo fmall, as that we might have rejected the fractional parts,

we ſhould have found the ſpace paſſed through in the ſecond ſecond of time, double that of the firſt."

W. "That is clear."

F. "But if the power of gravitation had ſuddenly ceaſed to act at the end of the ſecond ſecond of time, would not the body have fallen through 20 times 20, or 400 ſpaces, in the next two ſeconds?"

W. "Certainly; for in the laſt tenth part of the ſecond ſecond of time, it would fall through 20 ſpaces."

F. "Then, as it fell through 50 in the firſt ſecond, and 150 in the next, conſequently 200 in the firſt two ſeconds, the ſpace through which it falls in the ſecond two is double what it fell through in the firſt two, as in the former caſe."

W. "So I perceive."

F. "And, if we proceed with our inveſtigation in the ſame manner, we ſhall find, that, at the end of any given time, a falling body will have acquired ſuch a velocity, as would carry it through double the ſpace in an equal portion of time.

"How many feet does a body fall in the firſt ſecond?"

can be inflamed or detonated by the ſulphur and charcoal; for the cauſe of the immenſe power exerted by gunpowder is properly in the ſaltpetre."

W. "I imagined, the ſtrength of the powder lay in the flame; as you once told me, that air was greatly expanded by heat."

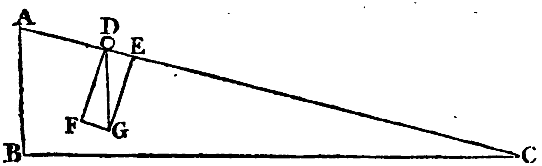
F. "This alone could by no means effect what we ſee performed by the inflammation of gunpowder; and it may be conſidered as an unqueſtionable fact, that, on firing gunpowder, an extremely elaſtic aeriform fluid, or *gas*, is evolved, which ariſes principally from the detonation of the ſaltpetre. Some future day I will ſhow you an experiment with the air-pump, from which this may clearly be inferred. Remember to put me in mind of it. This aeriform fluid has been found to occupy 250 times, or, according to others, 500 times the ſpace of the gunpowder, from which it was evolved, without taking into the account any expanſion from heat. Thus from one cubic inch of gunpowder are produced 250, or 500 cubic inches of *gas*, which muſt be expanded to four times this bulk, at leaſt, by the heat generated in firing the powder. Conſe-

the ſpace it would fall through in each ſucceeding ſecond, if the power of gravitation did not continue to act upon it. For inſtance, in three ſeconds it will acquire a velocity of ninety-ſix feet in a ſecond."

CHAP VII.

THE SKITTLE-GROUND.

Father. "We have lately inveſtigated the laws, William, according to which a body falls to the ground, when it can fall freely, that is, perpendicularly, and without hindrance. Let us now conſider the deſcent of a body on an inclined plane. For example, *how does the bowl roll down the run of a ſkittle-ground?* In order to find this, we will draw the following figure.



"Let A C be the inclined ſurface of the run: A B, it's height: B C, the baſe, or the

line the run would make if it were horizontal; and D, the bowl. Suppose, if the bowl were free to fall, it would fall perpendicularly in a given time through the space D G by the power of gravitation. This line D G, then, may represent the power of gravitation at the commencement of the motion of the bowl. What think you; will not his power be in part diminished?"

W. "Certainly; for if the run were horizontal, it would be completely destroyed; but, as the plane is inclined, it will be so only in part."

F. "Cannot you render this a little more clear by the resolution of the power?"

W. "We must resolve the power D G into two; one of which will be entirely destroyed, the other remain."

F. "Very well; go on."

W. "The first, therefore, must be perpendicular to the run, as D F, which will of course be destroyed by the resistance of the run; the other D E must be in the direction of the run, so this will have nothing to obstruct it."

F. "Then the absolute gravity of the bowl, will be to it's *relative* gravity, so we call

the power by which a body is impelled along an inclined plane, as D G to D E."

W. "Evidently."

F. "Now consider the triangles D E G, and A B C, you will find they are similar; for the angles A and D are the opposite angles of the two parallel lines A B and D G; and the angles E and B are both right angles. You have made sufficient progress in geometry to understand this, and to infer from it a proportion, which may be of service to us."

W. "It follows, that D G must be to D E, as A C to A B."

F. "What may we infer from this?"

W. "That the absolute gravity is to the relative, as A C to A B; that is, as the length of the inclined plane to it's height."

F. "Now suppose the inclined plane were 32 feet long, and 8 feet high, how many feet would the ball roll down in the first second of time?"

W. "As the height is exactly a fourth part of the length, it would descend a fourth part of the space it would fall through, if free, in the first second of time; that is a fourth part of sixteen feet, or just four feet."

F. "I need not remind you, that the

promifed him he would, the firft time they happened to be there alone.

Many of my young readers, no doubt, have feen a billiard table. They who have not fhould be informed, that it is a parallelogram, about twelve feet long and fix feet wide, covered with a green cloth, furrounded with a rim about two inches high, and having fix holes, to which pockets of netting are affixed, one at each corner, and one in the middle of each of the larger fides. Each of the players has an ivory ball, and a mace, or a cue, with which he impels it along the table. The mace confifts of a flat wooden head, the end of which is a ftraight line at right angles with the ftem; and the ftem, or handle, a flender ftick, about three feet long. The cue is a fimple ftick, about the fame length, fomewhat more than an inch in diameter at one end, tapering uniformly to about a quarter of an inch at the other, and cut flat a little way on one fide of the larger end. The principal object of the player is, fo to ftrike his own ball with the mace, or cue, that it fhall hit his adverfary's ball, and drive it into one of the pockets; his own ball at the fame time remaining on the table.

To teach the laws of the game is not our

falling freely, we muſt multiply the number of ſeconds by double the deſcent in the firſt ſecond; in our example, therefore, by eight. For inſtance, the velocity acquired by the bowl on this plane in three ſeconds would be that of twenty-four feet in a ſecond."

F. "Conſequently, in the caſe we are conſidering, it will always be the fourth part of the velocity of a body falling perpendicularly.

"Now let us inquire, how much longer time the bowl would take to deſcend down the inclined plane from A to C, than to fall perpendicularly from A to B.

"We formerly found the height of a perpendicular fall, as you may remember, by multiplying the ſquare of the time by ſixteen: the ſixteenth part of the height, therefore, muſt be equal to the ſquare of the time; muſt it not?"

W. "That is obvious."

F. "And we found the deſcent on our inclined plane by multiplying the ſquare of the time by four: ſo that the fourth part of the deſcent muſt be equal to the ſquare of the time."

W. "That is equally clear."

ſtrongly attached to the game, and ſo ſquander at a future period too much of his time and money. After he had learned the proper poſition of the body, how to place his left hand on the table, the manner in which the ſmall end of the cue was to be ſupported on the thumb and forefinger, and the proper management of his right hand in order to give the ſtroke, his father taught him how to ſtrike his ball, to make it rebound from the cuſhion ſo as to lie where he wiſhed it, or to hit his adverſary's ball with it, and drive it into one of the pockets.

That what I ſhall have occaſion to ſay may be intelligible to thoſe of my young readers, who have never ſeen a billiard-table, I have given a delineation of one. A B C D are the four corner pockets, E and F the two middle pockets. On the border at I and K are two braſs nails, called the ſtringing nails, between which an imaginary line is drawn, called the ſtringing line. The ſpace A B I K, within this imaginary line and the end of the table, being one-fourth of the whole table, is named the balk.

William, who had an accurate eye and a ſteady hand, ſoon learned how to play; but

the queſtion frequently occurred to him, "why muſt I play the ball in ſuch or ſuch a manner?"

"Very few billiard-players," obſerved his father, "know any thing of the laws of percuſſion. Indeed a man perfectly acquainted with them may be a very bad player at billiards; and a perſon totally ignorant of them may be a very good one. Yet, if a man, who has a certain degree of practical dexterity, underſtand the principles of what he does, it is ſo much the better, and not uſeleſs to him in the execution of it. If we ſuppoſe two players in other reſpects equal, that is, with equal accuracy of eye, ſteadineſs of hand, and practice at the game, one of whom adds a knowledge of the theory of percuſſion to his experience, while the other has no guide but his experience alone, the former will unqueſtionably beat the latter. The former acts from clear views; the latter has only an obſcure preſentiment of the effect. The former will err leſs frequently than the latter. When we get home, I will give you a few explanations of the rules, which I have been pointing out to you to-day in practice."

CHAP.

CHAP. XIII.

CONTINUATION.

F. "We will firſt conſider the ſtroke with a ſingle ball. When you play this againſt the cuſhion, it rebounds, as a ball does when thrown upon the ground or againſt a wall. What is the reaſon of this?"

W. "I do not underſtand clearly why it ſhould do ſo."

F. "I will tell you. A ball is elaſtic: conſequently, when any of it's particles are forced out of their place by preſſure, ſo as to alter the figure of the ball, they ſtrive to return to it again. Thus, when you throw your ball upon the ground, the part that touches the ground is preſſed flat, and endeavours to return to it's former figure, with a force proportional to that which was employed in compreſſing it: but this force cannot be ſpent on the hard and unyielding ground, and therefore drives the ball upwards. If you make a ball of any inelaſtic ſubſtance, as lead, or wet clay, and throw it upon the ground as hard as you will, it

will not ſpring up, becauſe the part that is flattened does not ſtrive to recover it's former ſhape."

W. "But I did not think an ivory ball, like that with which we play at billiards, could be compreſſed."

F. "There you were greatly miſtaken. You are not able to compreſs it with your hand, it is true; but a blow or fall, will compreſs it, as I will ſhow you. See, I will take a little greaſe and ſpread it here on the table, and lay this ivory ball gently upon it. You can ſee the place where it touched the table by the mark left in the greaſe. Now I will let it fall upon another place. What do you obſerve?"

W. "That the mark, which the ball has now made in the greaſe, is bigger than that, which it made when it was laid gently upon it."

F. "I need not aſk you what this proves."

W. "It proves, that a larger portion of the ball has touched the table; conſequently, it muſt have been ſomewhat flattened."

F. "It is juſt the ſame in playing at billiards: though here the rebound of the ball is not owing to it's elaſticity ſolely, but in a

"This is juſt the fact in the ſlope of the ittle ground, which rarely has the ſame in-ination throughout, and it's inclination is ill more varied by the oblique direction the owl takes *."

CHAP. VIII.

THE BALL.

WILLIAM, eagerly deſirous of improving s knowledge, reminded his father, that he id promiſed to explain to him the throw-g up of the ball.

* I am almoſt afraid, that the leſſons William has here ceived from his father, on the phenomena of gravita-on, may appear a little dry to a few of my readers; t they were neceſſary previous to ſome of the fol-wing articles: I have delivered them in ſuch a way, not to be above the comprehenſion of a youth at all cuſtomed to reflection; and I have too good an inion of my young readers, to ſuppoſe them deſirous being amuſed merely, without being inſtructed. A tle reflection, a little application, my dear young iends, muſt not frighten you, if you would acquire eful knowledge. Believe me, the acquiſition of owledge will amply reward you, for all the exertion u may beſtow in it's purſuit.

the latter is totally deſtroyed by it, and changed to it's oppoſite by the action of elaſticity.

"As ſoon as the ball has touched the cuſhion G, it is again impelled by two powers. It's own elaſticity, and that of the cuſhion, act upon it in the direction G H, perpendicular to the cuſhion; that power of the ſtroke which was not deſtroyed acts upon it in a direction parallel to G D; conſequently it muſt deſcribe the diagonal G B. But are not the triangles A G H, and B G H, perfectly ſimilar?"

W. "Yes; for the ſide G H is common to them both, A H and B H are equal, and the angles at H are the ſame in both, each being a rectangle; but if two ſides of one triangle, and the angle between them, be equal to two ſides of another and the intermediate angle, the two triangles muſt be alike; and, of courſe, the angles at G muſt be ſimilar."

F. "Very right. We know now, therefore, the law, according to which the ball rebounds from the cuſhion, namely, at the ſame angle, under which it was played againſt it. This law will guide a man,

would the power of gravitation act upon it n this time?"

W. "It would depress it four times sixteen feet, that is sixty-four feet."

F. "Consequently it would not arrive at C, but at B; thus, if C be sixty-four feet high, reaching the ground. If you draw the figure larger, you may divide the line of projection into more equal parts than I have done here, and thus obtain the curved line, which the ball describes in passing through the air. Thus, the ball impelled by the hand alone would reach the point I, midway between A and F, in half a second; and in the same time the power of gravitation would depress it one-fourth of sixteen feet, that is four feet. These four feet being set off on the perpendicular I H, we should find the point N, at which the ball would arrive in half a second."

W. "Might we not draw the curve line with a pair of compasses?"

F. "No: it is a line of a different kind from that of the circle, with the properties of which I shall hereafter make you acquainted, when you have advanced farther in the science of geography, for which, to my great satisfaction, you show so much aptitude. At present I shall only tell you the name of this

curve; it is called a *parabola.* But will the ball proceed in fact precisely in this line?"

W. "Probably the resistance of the air will make some alteration here too."

F. "It will; and a very perceptible one. Hence experiments of this kind will never be found to coincide exactly with the calculation.

"By this time, I imagine, you are able to perceive, why a ball, when thrown straight upwards by a person sailing in a boat, or riding in a carriage, falls down into his hand again, as well as if the person stood on the ground."

W. "The ball in this case is acted upon by three powers: by the hand, which impels it directly upwards; by the boat, which impels it horizontally; and by the power of gravitation, which acts upon it perpendicularly."

F. "Right. Suppose then that the hand in A impels the ball with a force that would make it ascend perpendicularly 32 feet, or to E, in one second, and that the boat moves from A to G in one second; these two powers, A E and A G, acting on the ball, would carry it through the diagonal line A F: in the mean time the power of gravitation would depress it to M, where it would be in the middle of the throw; and

in which the balls touch each other, L O, parallel to a tangent drawn through the point of contact. What conclusion may we draw from this?"

W. "The lateral power L O, which merely passes by the adversary's ball at the point of contact, can contribute nothing to it's motion; on the other hand, the power L N, which is perpendicular to the point of contact, acts wholly upon the ball, which must consequently move in the direction L N."

F. "You will, no doubt, be aware yourself, that the oblique stroke has it's limits. For instance, do you suppose it possible, to hole the ball M in the pocket C, if you play your own ball in the direction R O?"

W. "No; for then my ball would pass close by the ball M, without touching it so as to move it out of it's place."

F. "What then is the extreme, that limits the oblique stroke?"

W. "It is the stroke in which the direction of the player's ball makes a right angle with that which his adversary's should take."

F. "Right! the angle which the direction of the player's ball makes with that

which his antagoniſt's ſhould take, muſt always be an *obtuſe* angle. When it is but little obtuſe, or approaches a right angle, the adverſary's is ſaid to be a *fine* ball, and the player is ſaid to *hit it fine*, or *cut* it. The leſs the angle exceeds 90°, the finer the cut.

" A *perfectly full* ball, or a *dead full* ball, as it is commonly called, and a *very fine* ball, are the moſt difficult to play. A ball at a moderately obtuſe angle is eaſier.

" What we have conſidered hitherto, refers merely to the direction the ball played upon is to take. How far it will run, and where the player's ball will lie after the ſtroke, cannot be determined in ſuch a general way; for theſe will depend on the ſtrength of the ſtroke, and the weight of the ball. They will form ſubjects for our conſideration at ſome future time.

" That will give me ſo much the more pleaſure," anſwered the good youth.

Accordingly, when the afternoon arrived, Mr. Goodwyn repaired with his ſon to the field. Several ſhots miſſed the mark; whenever one hit it, the ſound of the drum announced it to the ſpectators. The drum beat, likewiſe, previous to every ſhot, as a warning to the company, to keep themſelves out of the way of danger; but this was far from ſufficiently heeded by many. William kept cloſe to his father, in a place perfectly ſafe, and enjoyed the ſhooting, the muſic, and the ſight of ſuch a concourſe of people, aſſembled on a fine day to partake in the general feſtivity. Piece after piece dropped from the wooden bird, which was placed at the top of a high pole; the diverſion ended with the approach of night; the crowd gradually diſperſed; and William returned home with his father.

" Would that powder and ſhot were never more to be employed, but for amuſement!" exclaimed Mr. Goodwyn: " that balls henceforward were to pierce only targets and wooden birds, not kill or wound men!"

" I cannot think how men ſhould ever

rate powers, which endeavour to move it round a third point in oppoſite directions. When this third point, or centre of motion, called the *fulcrum*, is between the other two, at which the moving powers act, it is a lever of the firſt order, and has either equal arms, like a common pair of ſcales, or unequal arms, like the ſteelyard.

"When the centre of motion is at one end of the lever, it is a lever of the ſecond order.

"Remember now the following law; *the powers acting on the lever are* in equilibrio, *when they are in the inverſe ratio of their diſtances from the centre of motion.*

"This law we find confirmed by experience in all caſes, and with this we will reſt ſatisfied for the preſent; but it is capable of demonſtration, without having recourſe to experiment, as you will learn hereafter, when you have made farther progreſs in the ſciences.

"Thus, when a conſiderable weight lies, or is ſuſpended near the centre of motion, it may eaſily be balanced or raiſed by a ſmall weight, if this be at a ſufficient diſtance from the centre. You may ſee this put into

At the first question William looked on his father with a smile, as much as to say, "a very puzzling question truly!" To the second he expected to find an answer in some of his books.

CHAP. X.

THE RIFLE-BARRELLED GUN.

Father. "WELL, William, are you ready with your answers to the questions I put to you yesterday?"

William. "Only in part. If you had asked me, why, when good aim is taken, and the piece is properly fired, the ball sometimes misses the mark; I should have answered, because the gun was not well made."

F. "Let us then consider the question, as I put it to you yesterday, a little more closely. What is it a man does, when he takes aim at an object with his gun? You know I have already allowed you to shoot with one sometimes, as I would have you learn how to handle such a thing, and to manage it with *prudence*."

the bucket cloſe to the edge of the table, for which purpoſe it's handle ſhould have a proper ſhape. If this be thick and round, the ſtem of the pipe will break; and indeed all pipes will not anſwer for the experiment."

William now made a little calculation concerning this experiment. He aſked John how much the bucket weighed, and was told about thirty pounds, for it was not a large bucket, and John had not filled it to the brim. William then borrowed a pair of ſcales of his mother to weigh the tobacco-pipe, and found it to weigh two ounces and a half. The bucket was ſo cloſe to the edge of the table, that he eſtimated the point of ſuſpenſion at no more than the tenth part of an inch, or a line from the fulcrum. So far he went on rightly; but he was about to make a conſiderable errour with regard to the weight of the pipe, by conſidering the whole of it as at the farther end, or in the bowl. His father informed him, however, that this weight lay in the centre of gravity of the pipe, which he might eaſily find by balancing the pipe horizontally on his finger. On trial, in this way, he found, that the centre

gravity of the pipe was twenty inches tant from the edge of the table.

F. " Now, to find on which ſide the pre- nderance muſt be, you have only to find : *momentum* on each ſide; that is, the ight, or power, multiplied by the diſtance m the fulcrum; and on whichever the *mentum* comes out greater, on that the ponderance will be. I need not caution ı, I preſume, that both the diſtances and ights muſt be reduced to ſimilar denomi- ions: thus you may expreſs the diſtances lines, the weights in half ounces.""

ccordingly William reckoned as follows:

	Bucket	Tobacco-pipe
ight	30 pounds	5 half ounces
	32	
	60	
	90	
	960 half ounces	
tance	1 line	200 lines
mentum	960	1000

ence he perceived, that the bucket could t preponderate, as the greater momentum s on the ſide of the tobacco-pipe.

CHAP. XVI.

THE HEAVY GOOSE.

WILLIAM had reflected on what his father had ſaid concerning the bucket and the tobacco-pipe, and thought he would poſe John in his turn.

W. "John, how far do you think you can carry a gooſe?"

J. "As far as you pleaſe, Sir."

W. "I believe not. I can ſet a gooſe upon your ſhoulder, that you cannot carry the length of our garden."

J. "What, a leaden gooſe, I ſuppoſe."

W. "No: the fat gooſe you killed this morning."

"I ſhould like to ſee that," replied John: for he was a ſtout youth, and thought his young maſter could not place a gooſe, that weighed only twenty pounds, in ſuch a poſition upon his ſhoulder, as to prevent him from carrying it to the next town and back again, if it were required. On trial, how-

ever, John was foiled, and found himſelf obliged to lay down the gooſe.

William had taken a ſtick ſix feet in length, at one end of which he hung the gooſe, and the other he placed upon John's ſhoulder in ſuch a manner, that the end, by which he was to hold it, was only half a foot from the point of ſupport. In conſequence, the diſtance of the gooſe from the fulcrum being eleven times that of John's hand, John was obliged to exert a power equal to eleven times the weight of the gooſe, or two hundred and twenty pounds, to keep it in equilibrium, and the two powers preſſed upon John's ſhoulder with a weight of two hundred and forty pounds, which was more than he could ſupport.

"That you may not have too high an opinion of your knowledge," ſaid William's father, "now let me aſk you a queſtion. If you and John were to carry the gooſe on this ſtick, each holding the ſtick by one end, and John be as ſtrong again as you, in what part of the ſtick ſhould we place the gooſe, that the weight each would have to carry might be proportionate to his ſtrength?"

William began to ſtudy, but was not ſoon ready with his anſwer.

F. "Would you be content, that the gooſe ſhould hang in the middle of the ſtick?"

W. "No: for then we ſhould have equal weights to carry; and, as I am the weaker, that would not be fair."

F. "Should it be nearer you, then; or John?"

W. "Nearer John."

F. How much nearer?"

W. "A fourth part."

F. You ſay this by gueſs. But if John knew what he were about, he would not allow it, for thus it would be too near him. If, however, we divide the ſtick into three parts, and hang the gooſe ſo, that it would be four feet diſtant from your hand, and two feet from John's, neither would have any reaſon to complain.

"With reſpect to you, William, John's hand is the fulcrum of the lever; the diſtance of the weight from the fulcrum is two feet, the diſtance of your hand from the fulcrum is ſix feet, or three times as much, ſo that

you have only one third of the whole weight to ſupport, or ſix pounds and two thirds of a pound.

"With regard to John, your hand is the fulcrum, the diſtance of the weight is four feet, and the diſtance of the power ſix feet, as before. Now ſince the former is two thirds of the latter, he muſt exert a power equal to two thirds of twenty pounds, or thirteen pounds and one third, which is juſt double that of yours, and conſequently the proportion required."

William perceived this, and wiſhed to know the rule for finding the proportion.

F. "It is very ſimple. We add the two numbers, which expreſs the relative proportions of the powers; as in this caſe two and one make three: we divide the lever into ſo many parts as the product gives, and we place the weight ſo that the parts of the lever on either ſide of it will be in the inverſe ratio of the powers. Thus, in the preſent inſtance, your hand would be twice as far from the weight as John's, to which we allow twice the ſtrength of yours."

CHAP. XVII.

WHAT ARE THE SMALLEST ANIMA WE KNOW?

"WHY do you keep that dirty wat that glafs, father?" faid Caroline: "i been there a long while; fhall I thr(away?"

F. "Not yet, my dear: I will firft fhov fomething very aftonifhing in it."

"Aftonifhing? What?" inquired (line, with eager curiofity.

F. "An immenfe multitude of l creatures, which you cannot difcern wit naked eye, but which may be rendere fible by a good magnifying glafs, or *m fcope.* Call William, it will excite w in you both."

While Caroline was gone for William, Goodwyn fet his microfcope in order, fcrewed in a lens with a very highly m fying power *.

* What microfcopes and magnifying lenfes ar be explained more fully hereafter.

William and Caroline came in, and ſtood ooking on with eager expectation.

F. " See this drop of liquor, which I have aken out of the glaſs: what do you pereive?"

C. " Nothing but dirty water."

F. " I will now place this drop on the lide under the microſcope. Caroline, you ook in firſt; then William: but you muſt ot move the microſcope."

C. " Bleſs me! it is all alive. Look, William, what a multitude of little creaures!"

W. " A multitude, indeed! and how faſt hey move about!"

Caroline and William could not enough dmire this wonderful ſpectacle. " What reatures are they?" " Why cannot we ſee hem with our naked eyes?" " How ſmall hey muſt be, for a ſingle drop of water to ontain ſuch numbers!" " Where did they ll come from?" Thus they went on with queſtion upon queſtion.

I doubt not, my young readers, but you would be equally aſtoniſhed, and equally inquiſitive, if you had an opportunity of ſeeing a ſimilar exhibition; and are at leaſt deſirous

of ſome further information, reſpecting this natural curioſity. I will therefore proceed, to give ſome account of it, which will unqueſtionably amuſe you.

Theſe creatures, the ſmalleſt with which we are acquainted, are called *animalcules of infuſion*. They are thus named, becauſe they are produced in infuſions, and are ſuch diminutive animals. For their production nothing more is required, than to pour water on any animal or vegetable ſubſtance, and let this infuſion ſtand four or five days in a moderately warm room, when a ſpecies of fermentation will take place in the liquor, a ſlimy ſkin will grow over it, and an immenſe multitude of theſe animalcules, viſible only by means of the magnifying glaſs, will be found in the fluid. They may be obtained from different vegetable ſubſtances, as I have obſerved; but from ſome more, from others leſs. They are produced in the liquor of oyſters; in infuſions of meat, pepper, or chopped ſtraw; and more abundantly in infuſions of hay, of a ſort of periwinkle, or of mignonette, an odoriferous flower, with which you are all acquainted, and many other flowers. From ſome flowers, indeed, I have

not ſucceeded in obtaining any: but it is probable, that I did not take them at a proper period. Of the numerous infuſions, however, with which I have made experiments, none afforded me ſuch multitudes of animalcula as thyme. If you put as much thyme as may be taken up between the ends of the thumb and two fingers into a wine-glaſs, fill the glaſs with pure water, and let it ſtand for four days, you will be truly aſtoniſhed, when you look at a drop of it through the microſcope. Millions of animalcules ſwim about in it, and the celerity of their motions is ſo great, that it makes the eye almoſt giddy. Figure 4 will give ſome idea of them; only you muſt conceive the animalcules to be infinite in number, and all in motion.

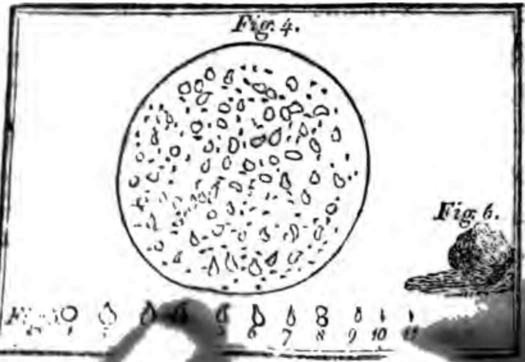
Wonderful! you will ſay:—whence do theſe creatures come? where were they before? why do they not appear, till the water has been poured on the herb, and ſtood on it ſome time?

It is wonderful, indeed, my young friends: and who is there, to whom theſe queſtions will not ſuggeſt themſelves, when he diſcovers an ocean of animated beings in a drop of

water, where a little before nothing was to be diſcerned?—But who can anſwer them?—Inſtead of ſtopping at theſe queſtions, we will purſue our obſervations themſelves a little farther, if you have any inclination to hear more of creatures, of which millions may be ſwept from the glaſs at one ſtroke with the point of the finger. Of their exiſtence I can entertain no doubt.

CHAP. XVIII.

CONTINUATION.



FIRS[illegible] [illegible]onſider animal[illegible]

fert, that they have perceived a difference in their figure, according to the fubftances from which they were obtained. I will not conteft it: though I muft fay, that I was never able to difcern this difference, in the obfervations I have made on various infufions. The animalcules in the infufion of hay, for inftance, appeared to my eye the fame as thofe in the infufions of thyme and mignonette. Variety in the figures and fizes of the animalcula I have obferved, it is true; but in the very fame infufion, not in the infufions of different fubftances. One and the fame animalcule, too, may affume different figures. The following are my own obfervations on the fubject.

The ufual form of the animalcules, when at reft, appears to be fpherical, or a little longifh, or egg-fhaped, as fig. 5, Nos. 1 and 2. When they are in motion, their bodies are more or lefs elongated, accordingly as they fwim about with more or lefs celerity, as Nos. 3 and 4. Some are feen darting along with great fwiftnefs, the figure of which is nearly linear, or refembling that of a fmall worm.

When the animalcules have this elongated figure, as in No. 3 and 4, we may clearly diſtinguiſh one end to be pointed, and the other pyriform, that is, ſhaped like a pear: and it is to be obſerved, that they always ſwim with the pointed end forward, whence we may conclude, that this is the head of the animalcule. This inference is confirmed by the obſervation, that the animalcule can make particular movements with this pointed or foremoſt end, of which I ſhall ſay ſomething more by and by.

With regard to the colour of animalcules of infuſion, I have almoſt always ſeen them clear and tranſparent as water; properly, therefore, without any colour. Sometimes, however, a few ſwim through the field of the microſcope, which are browniſh and opake; but theſe are much rarer than the tranſparent ones, and for the moſt part tolerably large.

In the thick or pear-ſhaped end may be diſcerned dark points, or curved lines variouſly croſſing each other, which ſome have conſidered as wrinkles in the ſkin of the animalcule; but it is probable, that they are internal parts.

CHAP. XIX.

CONTINUATION.

THE ſize of theſe animalcules, I mean their apparent ſize, varies greatly. With a glaſs that magnifies the diameter of an object three hundred times*, ſome appear about the ſize of a ſmall bug, ſeen at a diſtance of eight inches from the eye, others the ſize of a louſe, others ſtill ſmaller, and laſtly, at which I have been moſt aſtoniſhed, as were two of my friends, who obſerved it with me, among theſe larger animalcules in the infuſion of hay may be ſeen an infinite number of *minute animated ſpecks* ſwimming about, which, with this great magnifying power, appear no bigger than the ſmalleſt mite, or

* Magnifying powers ſhould always be reckoned thus, that is, according to the diameter. When the diameter is magnified 300 times, the ſurface is magnified 300 times 300, or 90,000: but ſome, who are fond of immenſe numbers reckon by the magnifying of the ſolid, which in this caſe would be twenty-ſeven millions of times.

fineſt grain of ſand, does to the naked eye, yet their voluntary motion is clearly perceptible.

Probably, too, the ſize of the ſame individuals varies, for no doubt they are at firſt ſmall, and grow larger from the nutriment they take. Probably thoſe infinitely ſmall points, that we obſerved in the infuſion of hay, were a numerous young brood, a new riſing generation of animalcules. If we examine an infuſion, of thyme for inſtance, on the third day, only a few animalcules will be ſeen, chiefly of a round figure, and neither ſo large nor ſo lively as on the fourth and following days, when they are conſiderably more numerous, briſk, and large. Some days after, when the infuſion has dried away a little, they again appear ſmaller and leſs lively.

You will aſk me, my young readers, how big the largeſt of theſe animalcules of infuſion may be: accordingly I ſhall endeavour to give you ſome conception of their minuteneſs. A grain of very fine ſand, when magnified to a certain degree, but far from the higheſt magnifying power, appears about the ſize of fig. 6. The largeſt animalcule of in-

fusion, with the same magnifying power, will appear at least six times less in diameter. Whence it follows, that upwards of two hundred of the largest animalcules of infusion may be contained in the space occupied by one of the smallest grains of sand. A little mite is to one of these animalcules much the same as a turkey is to a sparrow.

Reason here, you will say, is at a stand: a remark on no occasion more strictly true, than when with artificial aids we overstep the limits, to which nature has restricted our senses. What lies beyond the natural boundaries of our senses and imagination, reduces reason to a stand, as it is aptly expressed. Thus it is, when, availing ourselves of the magnifying power of the lens, we see a drop of water swarm with multitudes of living creatures; thus, when through the telescope we perceive the boundless space of the firmament filled with stars innumerable. At your age, my young friends, such a prospect excites for the most part astonishment merely: hereafter, when you have learned to consider these wonders in a higher point of view, a nobler and more exalted sensation will fill your hearts. May you become truly alive

to this ſenſation, and enjoy it in it's full extent.

CHAP. XX.

CONTINUATION.

As you do not appear to be weary of hearing of theſe little inviſible creatures, I ſhall proceed with the ſubject. We will now conſider their motions. You can conceive nothing more lively, than theſe animalcules: the buſtle of a neſt of ants, or ſwarm of gnats, is ſluggiſhneſs to it. They dart in all directions, like an arrow from a bow, acroſs the field of the microſcope, in ſtraight lines, when, as I before obſerved, their bodies are drawn out greatly in length. Sometimes they conceal themſelves under the ſlime of the liquor, as if they were ſeeking their nutriment there: then they reappear, ſwimming in various directions, and dexterouſly paſſing each other when they meet. Sometimes they draw their bodies up together in a ſpherical form, and then ſtretch them out again, in the ſame manner as a leech. Now they ap-

pear to dive down toward the bottom of the drop, as only their hinder parts are visible: presently they spin round like a top, with incredible velocity. When one of these animalcules has entangled himself in a particle of slime, it is pleasing to see how he whirls himself round with it, in order to extricate himself. It is equally pleasing to observe the motions, which they frequently make with the head, or pointed fore-end. When they give themselves a spring to dart forward, they frequently turn the head quickly on one side, as if they were biting at something, and swim forward with the head in this oblique direction, as at No. 5. One of my friends observed, that it looked as if they snapped at the little animated points I mentioned just now, and went in chase of them.

The longevity of these animalcules cannot easily be ascertained. Those that we contemplate under the microscope do not die a natural death, but are destroyed by the evaporation of the fluid, which leaves thousands of their dead bodies on the glass slide, in the shape of a little scarcely perceptible dust. It is observable, that, in an infusion, which has stood a week or more, they become smaller;

and at length ſeem to diſappear. Whether, however, theſe ſmaller animalcules be the ſame, which have gradually diminiſhed in ſize, or whether they be a more diminutive ſpecies, which at laſt alone remains, cannot be aſcertained.

The numbers of theſe animalcules ſurpaſs all conception. Since there are ſo many thouſands in a ſingle drop, what multitudes muſt there be in a wine-glaſs, that apparently contains nothing but a little dirty water! what, in a puddle, or ditch, where animal and vegetable ſubſtances putrefy together! How infinite this world of organized living beings, all of which are provided with inſtruments of motion and nutrition!

CHAP. XXI.

CONTINUATION.

It is not eaſy for any one, who has contemplated animalcules of infuſion through a good microſcope, to conſider theſe minute bodies as any thing elſe but living creatures. Yet, that they are ſo, has been denied: and

the great celebrity of the natural hiſtorian, who will not allow them to rank among animals, may give ſome weight to this hypotheſis; for which reaſon it deſerves to be noticed here.

The naturaliſt, to whom I allude, is no other than Buffon, with whoſe name and repute I preſume few of my readers are unacquainted.

" We need not be apprehenſive of going too great a length," he obſerves, " if we aſſert, that the grand diviſion of natural productions into *animals*, *vegetables*, and *minerals*, is far from compriſing all kinds of material beings." He conjectures, that " a cloſer ſcrutiny into nature will lead us to the diſcovery of certain *middle beings*; ſuch organized bodies, as do not poſſeſs like plants and animals for example the faculty of reproducing their like, though they have a *kind* of life and motion; or bodies, that are neither animals nor plants, yet may contribute to the compoſition of both; or beings, that are properly nothing more than an aggregation of organic particles." He is inclined to conſider *eggs* as belonging to the firſt of theſe claſſes; " and the moving corpuſcles, ob-

ſerved in the infuſions of fleſh, or ſeeds and other parts of vegetables, might be reckoned in the ſecond claſs of theſe equivocal beings. They are the organic particles, or primary aggregations of them, from which the organic bodies of animals and plants are compounded.

" Still farther to confirm this opinion, that theſe organic bodies are not real animals," continues Buffon, " we need only conſider attentively the appearances, that the experiments exhibit. Men have ſuppoſed theſe corpuſcles to be animals, becauſe they diſplay a progreſſive motion, and the obſervers have perſuaded themſelves, that they have ſeen tails to them*.

" May we not very reaſonably doubt theſe ſuppoſitions," he adds, " when we conſider, on the one hand, the ſudden and total diſcontinuance of the progreſſive motion begun, and on the other the reality of the ſuppoſed

* In all the animalcules of infuſion, that I have ſeen, I have never diſcerned any thing like a tail: it is poſſible, however, that there may be ſuch an appearance in ſome, as obſervers, whoſe accuracy and fidelity we have no reaſon to diſpute, mention it.

tails, which are nothing more than filaments, that the moving bodies draw after them * ?

"An animal moves now quickly, then flowly, and fometimes refts from motion.

"Thefe corpufcles, on the contrary, continue moving on in the fame manner, without ever repofing, and then renewing their movement. They continue to proceed onward without ftopping; and when they have once ftopped, they remain immoveable. Such a perpetual motion, uninterrupted by repofe, can by no means be confidered as the ordinary motion of an animal."

We might here be inclined to doubt, whether Buffon ever faw any animalcules of infufion, if it were not for the many experiments he relates with much prolixity. At the firft view through the microfcope we may fee, that the animalcules move fometimes fafter, at other times flower, now here, now there, reft from motion, and then move again, turn round on their own axis, &c. It is incon-

* The trace left behind in the water by the animalcule moving with fuch velocity may give the appearance of a tail.

ceivable to me, how Buffon could pen ſuch a palpable untruth.

"Beſides," he goes on, "let us conceive what animal we will, it muſt have ſome permanent form, and diſtinct limbs: but it is well known, that theſe moving corpuſcles are changing their figure every inſtant, have not one diſtinct limb, and their tail appears to be a mere accidental circumſtance."

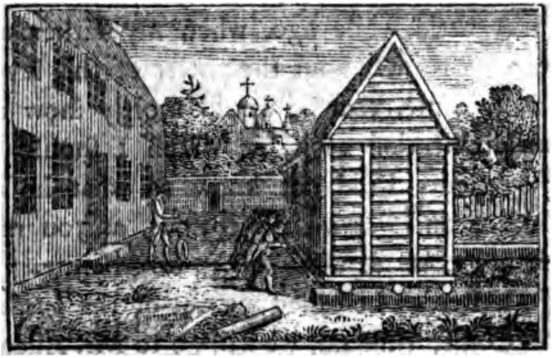
At the commencement of this paſſage the reader will immediately think of the leech, which, when it ſwims in the water, has a long extended figure, yet at times draws itſelf up into a very different ſhape. Exactly the ſame charge of form may be obſerved in the animalcules of infuſion, which always return to their common oval figure. Their change of form, too, is frequently in appearance alone, ariſing from their different poſition with reſpect to the obſerver's eye. The aſſertion, that they have no diſtinct limb, is confuted by the remark made above, that they move their heads, and turn them on one ſide.

From what I have here ſubjoined to the aſſertions of Buffon, I apprehend, it will ſufficiently appear, how little foundation

there is for the hypothesis, that denies animalcules of infusion the possession of proper animal life and perception. This may serve as a caution to you, my young readers, that we must not always rely implicitly on the assertions of a man of great name.

CHAP. XXII.

THE HOUSE REMOVED.



Dear Henry,

When you come to see us again, you will find great alterations. A house has been built on what was a vacant space: instead of an old building, that appeared tumbling

down, a large new one has been erected: and last of all, a whole house has been removed to some distance from the place where it stood.

"Removed to some distance," you will say: "yes, pulled down, and built up again in another place."

No, Henry; actually removed to another place in the proper sense of the words. I myself saw it done yesterday, and my head is so full of it, that I must tell you the whole of the affair.

A little while ago, when my father was talking to me about the power of the lever, he told me, that he would shortly show me an application of it, at which I should be surprised. I did not know to what he alluded, and was a little curious, as you may suppose, to see what was to surprise me.

Yesterday he called me out of the garden. "Come, William, we will go to Mr. Allen's, and see a house pushed out of the way."

I almost thought my father was in jest, but he looked seriously, and he is not apt to jest with me.

Accordingly we went, and presently we saw the business commence.

I know, my dear Henry, that you are older, and bigger, and know more than I; and will underſtand the buſineſs better yourſelf, than I can deſcribe it: but it is for my own profit and ſatisfaction, that I give you a deſcription of it; not to inſtruct you, which your tutor can do better.

The building, that was to be removed, was neither one of the pyramids of Egypt, nor St. Paul's church, as you may ſuppoſe; but it conſiſted of a two-ſtall ſtable and coach-houſe, the brick, and wood, and tiles of which, muſt be of ſome weight; and which ſtood ſo near Mr. Allen's houſe, as to render his yard very ſmall. He would have pulled it down, and built it up again farther off: but an ingenious carpenter told him, that he would engage to remove it as it was.

You muſt not be angry with me, Henry, if I ſeem a little tedious in telling my ſtory. I believe the carpenter would take leſs time to remove a houſe with his levers, than I do to give an account of it.

Firſt a trench was dug in the ground, ſo as to admit large beams to be placed under the frame timbers of the building, notches being firſt cut in the beams, to admit the

timbers. Under theſe beams ſeveral wooden rollers were placed: and theſe rollers reſted upon long balks, which they called ways, and which reached as far as the building was to go.

Once, my father told me, a church-ſteeple, with the bells and every thing in it, was removed ſome yards in this way, men chiming upon the bells at the ſame time.

The preparations, that I have been deſcribing, were made before we came: the work itſelf was now performed, and took up no long while.

About a dozen men were ſtationed with ſtrong levers in their hands, which they paſſed under the frame-timbers, the ends reſting againſt the ground. The carpenter gave the words of command: "one, two, three." At the word three, all at once bore againſt the end of their lever with the ſhoulder, by which the frame-timbers, and conſequently the whole building, were moved forward upon the rollers a few inches. They then halted, the carpenter examined whether the building had moved in a ſtraight direction, and whether the beams lay properly on the ways: the rollers were moved, as it was

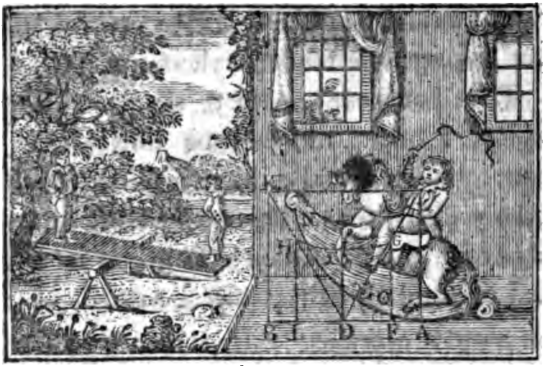
found neceſſary: the word of command was given again; and the building moved forward a few inches more. In this manner they proceeded, alternately applying the levers, and obſerving the progreſs of the building, till the ſtable and coach houſe arrived gradually at their deſtined place, without having ſuffered the leaſt injury.

Thus you have my ſtory, my dear Henry; which, I hope, will not be unwelcome to you: though I could have wiſhed you had been preſent, for we cannot ſee houſes moved about every day. Adieu! Think of us often, and particularly of thy affectionate,

WM. GOODWYN.

CHAP. XXIII.

THE SEE-SAW.



Father. "You are warm, William: what exercife have you been taking?"

William. "Charles and I have been fwinging, and playing at fee-faw."

F. "Very good. I am always glad to hear of your exercifing yourfelf: now is the proper time for it, while all your joints are fupple. Run, jump, dance, fwing, play at fee-faw, walk upon a round pole: all thefe exercifes promote corporal agility, which is of advantage to us on numberlefs occafions,

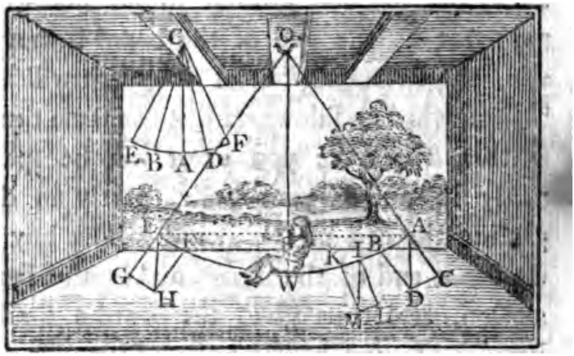
ſtrengthen the body, preſerve health, and impart cheerfulneſs to the mind. But, in the firſt place, be prudent in all your exerciſes, and not raſh: ſecondly, never beſtow more time on them, than your other occupations will allow. Neglect not the improvement of your body; yet purſue it in ſuch a way, that it may tend at the ſame time, to promote the improvement of your mind, inſtead of being injurious to it. Mental and corporal exerciſe ſhould be employed alternately to relieve each other: ſuppoſe we try, therefore, whether we cannot find ſome employment for the mind in a conſideration of the bodily exerciſes, with which you have juſt been amuſing yourſelf.

" For example, you are bigger and heavier than Charles; cannot you tell me, from the law of equilibrium with the lever, which I lately explained to you, how the board ſhould be placed upon it's ſupport? Suppoſe yourſelf to weigh fifty-five pounds, Charles only forty-five, and the board to be ten feet long."

W. " The weights are both diviſible by five, and, when divided by five, are to each *other as eleven* to nine. According to the

CHAP. XXIV.

THE SWING.



William. "O, that is a rope faſtened at both ends to a beam, I ſeat myſelf upon it, Charles ſtands behind me, gives me a puſh; and ſo it goes on, forward and backward."

Father. "Your 'O,' which, by the by, I cannot commend as an exordium, ſeems to imply, that there is nothing remarkable in the caſe: but let me aſk you, why does it go on, as you ſay, backward and forward? Or rather, why does it not continue to go on? for, if Charles did *not* repeat his puſhing every now and then, *the vibration of* the ſwing would ſoon ceaſe.

And, laſtly, how can a perſon ſwing himſelf, without receiving any puſh from another?"

William appeared to be puzzled by theſe queſtions, and looked as if he felt, that he had been a little inconſiderate at the outſet.

F. "We will ſuppoſe O W, in the drawing I have made, to repreſent the ſwing, made faſt to the beam above in O. If Charles pulls you backward, this muſt be in a ſegment of a circle, ſay W A; and when he has pulled you backward to A, the ſwing will be in the poſition O A. When you are at A, your body will gravitate perpendicularly downward. This power of gravitation we will expreſs by A D, and reſolve into two others, A C, in the direction of the rope, and A B, at right angles with it. What now do you perceive in theſe?"

W. "The power A C will be deſtroyed by the reſiſtance of the rope: the power A B will ſet it in motion."

F. "Right; for the latter acts in the direction the ſegment of the circle has at this place. Accordingly, if you were not to be puſhed forward, the power of gravitation would *ſet you in motion*, and this relative *gravity*, *A B*, would be to the actual, or

that exerted in falling freely, as A B to A D, by the principles of the inclined plane.

"But will the power A B be the ſame quantity in every part of the circle from A to W?"

W. "I think not. It will grow leſs and leſs."

F. "Certainly. For when you have arrived at I, if we take the abſolute gravity I M equal to A D, I K muſt repreſent the relative gravity, which will be obviouſly leſs than A B. And when you have reached W, where the rope hangs perpendicularly, what will the relative gravity be?"

W. "It muſt be nothing: for the abſolute gravity will be completely deſtroyed by the reſiſtance of the rope."

F. "So then no power remains to propel the rope farther?"

W. "No: for it has entirely vaniſhed at W."

F. "What then, will the motion ſuddenly ſtop, and the ſwing remain at reſt in the poſition O W?"

W. "No; that cannot be: for I know *by experience* it will go a great deal farther

the other way, and then come back again; but I do not know why."

F. "When your body has reached W, muſt it not have acquired a certain velocity from the preceding motion?"

W. "I did not think of that, but I underſtand it now. Though the power of gravitation cannot act upon it any longer at W, yet it will continue in motion from the velocity it has acquired in paſſing from A to W."

F. "And how ſhall we determine this acquired velocity?

"You ſay nothing: well, I will tell you. We muſt conſider this ſegment of a circle as an inclined plane, for it is the ſame thing, whether the body be confined to this path by an inclined plane down which it rolls, or by a rope to which it is ſuſpended; and we may conceive this ſegment of a circle as conſiſting of an infinite number of ſhort planes with decreaſing inclinations."

W. "Then the velocity, which the body has at W, will be exactly equal to what it would have acquired in falling perpendicularly as far as W is below the line A E.

F. "Consequently the body will proceed with this velocity in the same curve from W toward E. But now the power of gravitation acts counter to it's motion; and this the more, in proportion as it's distance from W is increased. What follows from this?"

W. "The body will continue losing more and more of it's velocity."

F. "Till it is entirely annihilated; which will be when it has arrived at E, through the curve W E, which is equal to A W, through which it descended. For, you will observe, the action of gravitation will be precisely equal in both curves, but in opposite directions; so that the velocity, which was acquired in the curve A W, will be again lost in the curve W E, which is exactly equal to it.

"What is the law that we have now discovered?"

W. "Bodies ascend in curves equal to those, through which they have descended."

F. "But is not the body at E in the same situation as it was in before at A?"

W. "Precisely."

F. "What follows from this?"

W. "It will ſwing back again from E to A."

F. "And then again from A to E, and ſo on. Now you know why it continues to go on backward and forward, do you not?"

W. (With a ſmile.) "I believe I do: and perhaps I could now anſwer the ſecond queſtion, why the motion ceaſes, if a freſh impulſe be not given to the rope every now and then. The cauſe of this, I ſuppoſe, is the reſiſtance of the air."

F. "Your ſuppoſition is not amiſs; for this muſt continually operate to retard the motion, and is ſufficient of itſelf to put a ſtop to it gradually. But beſide this, the friction of the rope againſt the beam, and it's not yielding perfectly to the motion at the top, where it muſt bend a little in ſwinging, contribute ſomething to retard the movement.

"My third queſtion, how a perſon can ſwing himſelf, we will conſider another time. At preſent let me aſk you, are the vibrations quicker when the rope is longer, or when it is ſhorter?"

William knew from experience, that with a long *rope the* vibrations were ſlower than *with a ſhort* one.

F. "If, then, we would have a rope ſwing with double the velocity of another rope, how much ſhorter muſt it be?"

W. "As ſhort again."

F. "No, no, William; that would not do: it muſt be four times as ſhort. You ſhall ſee it proved by experiment: at preſent I cannot give you a general demonſtration of the problem.

"See here is a leaden ball, ſuſpended by a ſlender line, three feet long, which I will ſet in motion. Take my ſtop-watch, and obſerve how much time it takes to vibrate backwards and forwards: you will find it is juſt one ſecond in vibrating either way. This, therefore, is a ſecond pendulum.

"Here is another pendulum, only a fourth part ſo long, or nine inches. Compare their vibrations, and you will find, that this makes exactly two, while the former is making one.

"This little pendulum, which is only four inches long, you will find, makes three vibrations, while that of three feet, which is nine times as long, makes one.

"Now, I ſuppoſe, you yourſelf can tell *the law* according to which theſe act."

W. "*The lengths of the pendulums are as the ſquares of the times in which they vibrate.*"

F. "Exactly. Of this I ſhall ſome time or other give you a demonſtration.

"Pendulums are of great uſe in common life; chiefly for regulating the motions of clocks, and rendering them uniform. To this purpoſe they were firſt applied by Chriſtopher Huygens, in the year 1657."

W. "I have long had it in my mind, father, to aſk you to ſhow me how clocks are made."

F. "With a great deal of pleaſure, William: and I will take ſome early opportunity of doing it; for I am glad to find, that this ingenious and uſeful machine has engaged your attention."

CHAP XXV.

SOMETHING NEW ON THE SUBJECT OF SPIDERS.

"THESE filthy ſpiders" ſaid Caroline, *ſweeping* down ſome cobwebs with a bruſh

"are ſpinning their webs in every corner, if we be not continually deſtroying them."

"You do not like to have them in the houſe, Caroline," ſaid her father: "and, it muſt be owned, cobwebs are not very conſiſtent with domeſtic cleanlineſs. Yet, would you ſuppoſe it, there are people, who take a pleaſure in having a number of ſpiders about them."

C. "How can any perſon delight in ſuch ugly creatures!"

F. "Nay, at the loſs of a ſpider a man has felt ſo much, as to endeavour to put an end to his own exiſtence; and what is more, a ſpider has decided the fate of thouſands of men, and of whole countries."

C. "If any other perſon told me ſo—"

F. "You would not believe him. If, however, my children, you have any wiſh to hear ſomething both important and amuſing reſpecting theſe ugly, filthy creatures, as you, Caroline, and many others call them, I will relate to you ſome facts, at which you will not be a little ſurpriſed."

"O tell us all about them!" exclaimed *both* William and Caroline together, "we *like to hear* ſuch things."

F. " A nobleman in France, I think it was a count of Lauzun, was condemned to a rigid imprisonment. Cut off from all human society, and allowed no means of diverting his solitude, he made a companion of a spider, who had spun her web in a corner of his cell. He at length familiarized her so far, that she would come upon his hand, and eat from it a portion of his food, which he gave her. The jailor, totally devoid of feeling, thought this too great an indulgence for the unfortunate prisoner, and crushed the spider to death. The count, thus bereft of all occupation, and deprived of the only living being about him, in a fit of despair dashed his head against the wall, and would have beaten out his brains, had he not been prevented."

" Poor man! Execrable jailor!" exclaimed Caroline and William.

F. " I will now relate to you another anecdote of a prisoner, more recent, but less tragical. In the year 1787, when the Prussian army entered Holland, under the Duke of Brunswick, Quatremere Disjonval, an adjutant-general in the dutch service, who *had taken* part against the stadtholder in the

commotions in the United Provinces, was thrown into prifon. Here he remained till 1795, when he was releafed, on the arrival of general Pichegru, at the head of a french army. During the feven years of his confinement, he had nothing to amufe him but the fpiders in his prifon, which he had tamed. He had gathered about him a great number of thefe, of different fpecies, and the obfervations he made on their manners and habits of life alleviated the irkfomenefs of his folitary hours. His obfervations on this fubject he has arranged in order, and publifhed in a little book, with the title of *Araneology*. Thefe obfervations are in part new, and among other things confute the charge made againft fpiders, that they devour one another. It is true, they do this fometimes, but it is only when they can procure no other food, and are driven to it by neceffity. Thus Reaumur, a celebrated french naturalift, collected together a great number of fpiders, in order to try whether their webs might not be applied to the purpofe of manufactures, as well as thofe of the filk-worm. The fpiders were fo numerous, however, that they could not find a fufficient number of flies and other

infects for their food, fo that in a fhort time they were obliged to feed upon one another, and thus the hope of obtaining profit from their labours was fruftrated. It is a fact, notwithftanding, that ftockings of great finenefs and warmth, and of confiderable ftrength, have been fabricated from cobwebs.

"The moft remarkable obfervation of our prifoner, Mr. Disjonval, was, that fpiders are particularly excellent as prognofticators of changes in the weather, being more certain than the barometer, giving their indications a longer time beforehand, and having this advantage to the lower clafs of people, that they coft nothing.

"On the common houfe-fpider, for example, he has made the following remarks. Againft fine weather, it peeps out it's head, and ftretches it's legs out of it's hole, and this the farther, the longer the fine weather will continne. Againft bad weather it retires farther back: and againft very tempeftuous weather it turns quite round, fhowing nothing but it's hinder parts to the obferver, thus acquainting him with the approaching change of the weather. At the commencement of fine weather, the web, with which

it ſurrounds it's corner, is but of moderate extent: if the fine weather will be laſting, it enlarges it two or three inches; and if it do this ſeveral times repeated, we may be certain, that the weather will continue fine for ſome time.

"On the 22d of july, 1795, Mr. Diſjonval foretold, from the behaviour of his ſpiders, a fortnight beforehand, that the water of the Rhine would fall ſo, as to render it paſſable by a bridge of boats; and in this manner it was actually paſſed.

"In winter they are as certain prognoſticators of approaching cold. If froſt and ſnow be coming on, they either ſeize upon webs already made, in which caſe obſtinate battles frequently enſue, or they make new ones, and labour diligently at them. Diſjonval found, from ſeveral attentive obſervations, that, from the firſt of the ſpiders putting themſelves in motion to the ſetting in of the froſt, nine days generally elapſed. We have a ſtriking inſtance of the juſtice of this obſervation in the beginning of February 1793. The weather was fine, warm, and there was no ſymptom of approaching froſt. It might have been ſuppoſed, that fires wou

be no longer required: but on the 4th of february, Mr. Disjonval announced, that a great alteration in the weather would ſoon enſue, as, beſide other remarks of a ſimilar kind, he had ſeen three ſpider's webs, one over another, in a place where there was not one the preceding evening. On the 9th of february there was ice, and by the 13th all the canals were frozen over. It was now probable, that with the breaking up of this froſt the winter would terminate. This was the opinion of Mr. Disjonval himſelf: and he felt no ſmall ſatisfaction, in having been able to foretel the freezing of the canals to a whole town, when ſuch a circumſtance was leaſt expected. A complete thaw in fact came on; but on a ſudden he obſerved, contrary to all expectation, a general buſtle among his ſpiders on the laſt day of february. They ran backwards and forwards, began to ſpin webs diligently, and attacked one another. Hence he inferred, that ſome remarkable change was taking place; and that very dry weather at leaſt, if not very cold, would enſue. This conjecture he announced to the principal bookſeller in the *town, and* through him to the public. Two

days after it rained, which seemed no way favourable to his prognostication; and this rain continued for five days, so that the validity of his prediction appeared daily more questionable. Still, however, attentive to the proceedings of his spiders, he wrote every day to the same bookseller, telling him he continued firm in the persuasion of the approach of cold or dry weather. On the 8th of march it blew hard; on the 9th it snowed; and on the 10th the frost was so sharp, that all the canals were frozen over again.

"The greatest and most striking instance of the importance of these observations, and the dependance that may be placed on predictions respecting the weather from them, is the conquest of Holland by the french in the winter of 1794-5. Disjonval's keeper was inclined to the patriotic party, and in consequence treated his prisoner with less strictness. Through his means Disjonval gave notice to the patriots, that a hard winter would ensue, which would render all the rivers and canals passable on the ice. The taking of the town by the french afforded him the only hope of being emancipated from his long imprisonment: it may

be ſuppoſed, therefore, that he obſerved his ſpiders with the utmoſt care and attention. In the beginning of december he heard, to his great alarm, that the people talked of a capitulation, which would have annihilated his hopes at once. He uſed every means in his power, to make known, that, from the operations of his ſpiders, a very ſevere froſt would inevitably come on, and this within a fortnight at fartheſt. The people gave credit to his prediction, did not capitulate, and on the 29th of december the froſt was ſo hard, that the french were able to paſs the Waal. The ariſtocratic party flattered themſelves, notwithſtanding, that the froſt would ſoon break up, as on the 12th of january the water roſe, and was turbid, which was conſidered as a certain indication of a thaw. Disjonval, in the mean time, wrote from his priſon to the editor of the Utrecht gazette, that, before three days had elapſed, a more ſevere cold than the former would take place. On this occaſion the ſpiders proved incomparably better prophets than the turbid water; on the 14th of january the wind roſe, on the 15th it froze, and on the 16th the french

entered Utrecht; thus the prifoner regained his liberty.

" He continued carefully to obferve the fpiders he could find, in order to give the french general frefh information, which was of fuch importance to him in this daring enterprife. On the 20th of january a fudden thaw came on. The general was alarmed for the fate of an army of a hundred thoufand men, with a train of artillery, and began to think of a fpeedy retreat. But Disjonval had recourfe to his fpiders, and they foretold froft. He fent a couple of thefe little prophets to the french general: they were credited, their prophecies were fulfilled, and the french conquered Holland.

" Such a ftriking circumftance induced the french executive directory to inftitute an inquiry into this new branch of knowledge; obfervations will be made, moft probably, in other countries; and thus thefe *odious* fpiders may be found of great importance in meteorology, and confequently of great ufe in common life."

CHAP. XXVI.

THE TREE FROG.

WHILE we are on the ſubject of prognoſticators of the weather, it may not be amiſs to mention two other animals, which poſſeſs this remarkable and uſeful faculty of foretelling changes in the atmoſphere, by their actions, with tolerable accuracy. One of theſe is the dog. When dogs eat graſs, we commonly infer, that rainy and ſtormy weather will come on. But the tree frog, or green frog, is much more diſtinguiſhable for this faculty; on account of which it is kept in glaſſes, in many parts of Germany, as we keep gold-fiſh, and fed with live flies. Of this frog I will give you ſome account.

The tree frog is diſtinguiſhable from other ſpecies by it's form, voice, and mode of living. It is of a ſmall ſize, graſs-green colour, and has four little round warts, or knobs, on the fore-feet, and five on the hind-feet. The hind-feet only are webbed, *and not* more than half-way up the *toes; yet, which* is remarkable, it ſwims

faſter than moſt other frogs. The ſkin under the throat is pendulous, or hangs looſe; but more ſo in the male than in the female. By means of the warts on the toes it can adhere to the ſides of the glaſs, or other ſmooth ſurfaces; and in this it is aſſiſted by the ſkin of the throat, which likewiſe it ſticks, as it were, to the glaſs. This adheſion to a ſmooth perpendicular ſurface may be owing to two cauſes. The whole body is covered with a kind of ſlime, and a glutinous moiſture exudes from the warts, by means of which it may ſtick to the glaſs by coheſion. The *preſſure of the air* is probably another cauſe: for, that this coheſion alone is not the cauſe, that enables the frog to ſtick to the glaſs, is evident from the circumſtance, that the frog cannot ſtick to the ſides of the receiver of an air-pump, when the air in it is rarefied, but always falls down. Hence it appears, that the warts on the feet act as thoſe ſuckers, with which boys lift up ſtones. With one of theſe warts ſingly the frog can fix itſelf to the cover of the glaſs, ſo that it's whole body hangs ſuſpended from it.

The voice of the tree frog has very little reſemblance to the croaking of other ſpecies.

It confifts in a continued creak, much like the rubbing of a blunt file againft a piece of fteel, or the back of a knife againft an earthen plate. You may deceive the tree frog in this manner, particularly in the evening, fo that it will anfwer you with it's voice, when it hears this noife. It is only the male, however, that emits this found, and not before he is three years old. To make this cry, he fwells up the fkin of his throat like a thick round bladder, the fides of which fhrink in, while he forcibly expreffes the air from it. It is commonly in the evening after funfet, and in the morning at day-break, that this cry is heard.

Thefe frogs inhabit moft parts of Europe, though we have never heard of one found in England. When they are at liberty, they abide in the water during the fpring; but in fummer they live moftly on the land, climbing up trees, and feeding upon infects. In winter they bury themfelves under ground, and remain torpid as long as the cold weather continues. In a glafs, however, in a warm parlour, the tree frog will remain for weeks fixed to one fpot, and can live two or three months without food. If a live fly be thrown

into the glaſs, the frog catches it with a leap, which is ſo well aimed, that it fixes itſelf to the glaſs at the ſame time with all four feet. A dead fly it will not touch: and it never leaps after a fly, that remains without moving, but ſits ſtill, watching it with fixed and ſtaring eyes. The moment the fly begins to move, the frog ſprings on it with extraordinary agility and certainty, and ſnaps it up, uſing for this it's thick rough tongue, rather than it's lips. It eats ſpiders, and other inſects, likewiſe; and may be deceived with other things, that look ſomewhat like inſects, if they be ſet in motion. Thus if a piece of a prune be faſtened to a horſe-hair, and moved a little, ſo as to have an appearance of being alive, the frog will leap at it; which it would not, if the bit of prune were laid down, or held ſtill.

The remarkable ſenſibility of this animal to changes in the weather renders it a kind of barometer, and we may frequently find it's intimations deſerve more confidence, than thoſe of the riſing or falling quickſilver. When the tree frog dives into the water at the bottom of the glaſs, we may be pretty certain, that it will rain ſoon. If it remain-

long in the water, the rain will continue ſome time. During the continuance of the wet weather, it will abide principally in the water, and be tempted to leap out of it only by a fly, or ſome other prey. If the weather be very bad, the frog will be reſtleſs, or lie ſtretched out as if dead on the bottom of the glaſs, or appear convulſed. On the other hand we may expect fine weather, when the frog attaches itſelf firmly to the glaſs above the ſurface of the water, or climbs up a little ladder, that is placed in the glaſs. The cry of the male, too, denotes dry and ſe[illegible] weather.

CHAP. XXVII.

OF THE RATTLESNAKE.

Most of my readers, I preſume, have heard of the rattleſnake, of which ſo many wonderful things have been told. It certainly deſerves notice: and it is alſo proper, that the fabulous accounts given of it ſhould no longer be allowed to paſs current. In *all things* truth ſhould be our aim, and we

ſhould never overſtep its limits on any account. Is it not abſurd, to recur to fable for the marvellous, when there is ſo much to excite our wonder and admiration in the plain facts, that nature exhibits to our obſervation?

This terrible animal is an inhabitant of America, and frequents woods and moraſſes. There are different ſpecies of it; ſome blackiſh, others of a reddiſh yellow colour, others of a yellow red, and brown, ſtreaked with black lines. They differ in ſize like- [illegible] the largeſt growing to the length of eight feet, and the thickneſs of a man's arm. This genus of ſnakes is diſtinguiſhed from all others by the rattle at the end of the tail; which is of a browniſh colour, conſiſts of ſeveral horny joints, moveable on each other; and makes a rattling noiſe when the ſnake moves, whence it derives it's name.

The bite of the rattleſnake is extremely fatal, on account of the ſtrong poiſon which it inſtils into the wound it makes. This poiſon is contained in a ſmall bladder beneath each of the fangs of the upper jaw, and is collected there in the largeſt quantity, when the animal is irritated. The fangs are

hollow, and have a ſmall aperture, through which the poiſon paſſes into the wound. This poiſon kills the largeſt beaſts, as a horſe, or an ox, almoſt inſtantaneouſly. If a man have the misfortune to be bitten by one of theſe ſnakes, he has little chance for recovery, if the wound be not preſently cauteriſed with a hot iron, or ſome cauſtic applied to it, which is ſtill preferable. The negroes make uſe of the cautery for the purpoſe. There is nothing appears externally in the part bitten, except a couple of little holes like flea-bites, into which the [illegible] have penetrated. But a ſwelling ſoon comes on in the part, and ſpreads inceſſantly, till it occupies the whole of the limb, and at length extends over all the body, the tongue growing ſo thick, that the paſſage of the throat is ſtopped up. Immediately after the bite the perſon feels an uneaſineſs, which gradually increaſes, till at length a mortal anxiety comes on, with burning thirſt, and terminates in a lamentable death, if timely recourſe be not had to the proper remedies.

The poiſon of the ſnake, however, is confined to the two fangs, there being no viru-

lence in any other part of the body. The fleſh is nutritious, and well-flavoured, and is eaten by the Indians without injury. To obtain it they approach the animal behind, and ſtrike it dead.

The rattleſnake is particularly noted for the manner in which it takes it's prey. Much that is erroneous has been ſaid upon this ſubject, and a power of faſcination has been aſcribed to the animal. That it's prey very frequently acts as if faſcinated, is true; but this ariſes from another cauſe. The [illegible]ſnake does not climb up trees, but frequently ſearches among the low buſhes for young birds. When the mother-bird finds her neſtlings in danger, her affection for her young prompts her to their defence, ſhe flutters about the ſnake, attacks it with her beak and claws, retreats a little from the danger, and almoſt inſtantly returns to the attack. Sometimes ſhe is ſucceſsful, but often ſhe becomes the victim of her maternal heroiſm, and the ſpectator, who has ſeen her apparently fly into the mouth of the ſerpent, aſcribes it to faſcination. Some of you may have read this very circumſtance deſcribed by Homer, who was a very

accurate obſerver of nature, above 2000 years ago, in the ſecond book of his Iliad, l. 310.

It is not improbable, too, that the effluvia of the animal may have a ſtupifying effect on ſome animals, at leaſt within a certain diſtance: for we are told by Dr. Michaelis, a phyſician at New-York, that once, while he was making a courſe of experiments on the poiſon of the rattleſnake, he felt himſelf ſtupefied by the effluvia of one, as if he had been in a ſtate of intoxication, ſo that he threw himſelf on his bed, and was h[illegible] hour before he completely came to himſelf again.

There are inſtances related, likewiſe, the truth of which we have no reaſon to queſtion, of perſons, who, on ſeeing rattleſnakes, have been fixed to the ſpot, ſo that they could not run away. This, however, muſt be aſcribed to the power of imagination. A man, into whoſe mind this belief of their power of faſcination had been inſtilled, ſuddenly perceives a rattleſnake near, with his eyes fixed upon him. Is it wonderful, that his *unfortunate* prejudice, and the fright *with which* he is conſequently ſeized, ſhould

prevent him from making any attempt to eſcape, when he firmly imagines, the attempt would be vain? Such a man has been ſaved by his companion, whoſe imagination was leſs powerfully impreſſed by the idea; and made to feel, that nothing was wanting to enable him to flee, but the exertion of his will. In all ſituations of danger, men who conſider themſelves as loſt, either make no attempt to eſcape, or know not how to effect it. This is what we call want of preſence of mind: a valuable quality, the ad[illegible]ges of which, as well as the miſchiefs ariſing from falſe impreſſions, are obvious in the inſtance juſt given, and in numberleſs occurrences of common life.

CHAP. XXVIII.

SINGULAR ACCOUNTS RESPECTING TOADS.

To go on with theſe *odious* creatures, as too many inconſiderately call them, we ſhall paſs from ſpiders, frogs, and ſnakes to the toad.

Toads are held in abhorrence by ſeveral *perſons*; and ſome are ſo much afraid of

them, that the fight of one is fufficient to make them run away, or even faint. Very few, indeed, have courage to handle them. It muft be owned, their appearance is not very engaging; they are foft, flimy, and filthy, to the touch; they live in wet, low, marfhy, dirty places; have a flow, crawling motion; and from thefe circumftances probably they are commonly reputed venomous.

I confefs myfelf, I like the lively flitting redbreaft better than the crawling, dufky green toad; yet this animal is unqueftionably innocent of the poifonous qualities afcribed to it, as many have proved by repeated experiment. It has no fangs, to inftil venom by it's bite: the glutinous juice, that exudes from the warts or pimples on it's fkin, is not poifonous, for toads have been repeatedly handled without injury, and quacks have exhibited the difgufting trick of fqueezing their juices into a glafs, and drinking them with impunity; and in the fame manner it has been proved, that it's urine is equally innocuous. The moifture it preferves in a particular bladder has been fuppofed by fome to be *poifon*; but Mr. Townfon, who

has very accurately examined theſe animals has found it to be nothing but clea water.

The toad is capable of being domeſticated and rendered very tame and familiar. A gentleman was accuſtomed to feed a toa regularly for ſix and thirty years, and ever evening, as ſoon as the toad ſaw the cand lighted, it would come to the table, i order to be lifted up on it for it's ſupper, cor ſiſting of the maggots of the fleſh-fly, whic were it's favourite food, and various kin of inſects. Theſe it would follow, an when within a proper diſtance, would fix it eye, and remain motionleſs for near a qua ter of a minute, as if preparing for th ſtroke, which was an inſtantaneous dartir it's tongue to ſome diſtance upon the in ſect, which ſtuck to the tip by a glutinou matter. This motion of the tongue quicker than the eye can follow. The toa here mentioned was called the old toad b this gentleman's father, when the gentlema firſt knew it, and at laſt it's death was o caſioned by an accident, ſo that it muſt b a pretty long-lived animal.

Indeed what is moſt remarkable in the toad is it's tenacity of life. Live toads have been found more than once encloſed in ſolid ſtone, or wood, which muſt have grown round them, and in which they muſt neceſſarily have been confined many years. The following are a few inſtances of this kind.

A large block of ſtone was ſeparated from a quarry in Sweden, and as one of the workmen was hewing it into ſhape, he found within it a living toad. It's back was duſky, and a little ſpotted, it's belly of a ſomewhat lighter colour, and the whole body was in a manner incruſted with little fragments of ſtone. The eyes were ſmall, round, yellow, and covered with a tender tranſparent ſkin. The aperture of the mouth, too, was cloſed by a yellowiſh ſkin; but beneath this, in each jaw, were found two ſharp teeth. It made ſcarcely any motion, except that it cloſed it's eyes when preſſed gently on the head with a ſtick. On being preſſed hard on the back, it emitted ſome cold water, and preſently after died. The men attempted to cut out the piece of ſtone, in which the

figure of the toad was impreſſed, but it crumbled to ſand.

In the year 1764, a live toad was found in a quarry in Lorrain, fifteen yards below the ſurface of the earth; and the quarrymen affirmed, that it was the ſixth found there, encloſed in the ſtone, within the period of thirty years.

In the year 1771, a wall was pulled down in France, which was known to have ſtood above a hundred years. Encloſed in the maſonry a toad was found, not alive it is true, but to all appearance very lately dead.

In 1719 a toad was found in the root of an elm, which was as thick as a man's body. The hole it occupied was exactly the ſize of the toad, and when the wood was cleft it crawled out. On examination, no chink or aperture could be diſcovered, through which it had entered.

In 1731 a ſimilar circumſtance occurred in an oak of ſtill larger ſize.

In 1780 a live toad was found in the trunk of a large oak, fifteen feet from the root, ſo grown in as to be completely ſurrounded with ſolid timber. It was ſtruck by the axe in hewing the wood, yet ſtill moved,

and appeared to be very old and feeble. The timber round it was perfectly found, without any hole or chink.

These instances occurred in France; the following more recent was in Germany.

On the 26th of december, 1795, as some quarrymen were cutting a very large stone into smaller blocks, they found in it three live toads, two large and one small, in an oblong hole, varnished over internally with a yellowish-brown matter. No other hole was perceptible in this stone: there was no appearance of any communication between this cell and the external air: and the stone near it was equally hard as in other parts. They were not willing to quit this hole, in which it is impossible to say how long they might have resided; and when they were driven out, they leaped in again. At length, being forced upon the neigbouring grass, they hopped about briskly, and were not easily kept together; but in the course of half an hour they all died.

Instances of living toads included in solid stone have occurred in different parts of England likewise.

From the inſtances related above to happened in France, Mr. Heriſſant, a fi naturaliſt, was induced to make the fo ing experiments.

On the 21ſt of february, 1771, he three live toads, and encloſed them deal box filled with plaſter of Paris, ea a ſeparate hole, the plaſter of Paris l powdered and wetted, and covering t on all ſides to ſome thickneſs. On the of april, 1774, which was more than years afterwards, he opened the box. middle one, which was the largeſt, he fo dead, perhaps becauſe it was too tig jammed in: the other two were alive well.

In what manner can theſe ſingular be explained? How the toads in the mentioned above got into the ſtone, or w how long they lived there, and on what lived, are queſtions not eaſy to be ſolve

With regard to the firſt, it ſeems ſca ſuſceptible of any other anſwer, but that egg muſt have fallen accidentally into matter, that compoſed the ſtone, while was ſtill ſoft; or into the tree, as it bega

ſprout form the ſeed. Form this egg the animal was gradually developed, and grew, while the ſubſtance that ſurrounded it yielded to it's extenſion.

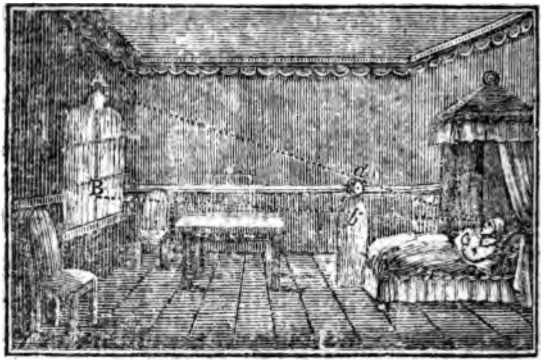
In the ſtone, indeed, it might be ſuppoſed, that the animal had attained it's full growth, whèn it was firſt enveloped by the ſoft matter, that afterwards hardened into ſtone; but in the caſes of trees this ſuppoſition ſeems inadmiſſible.

As to the ſecond queſtion; how long have theſe toads remained in their holes? we can only ſay, from the time when the ſtone was a ſoft maſs, and the tree firſt began to grow. But when we reflect on the length of time an oak takes in growing up to a large tree, the age of the animal muſt aſtoniſh us. It ſeems ſcarcely credible, that an animal ſhould remain motionleſs for a hundred years or upwards, during which it could neither employ it's feet in walking, it's mouth in eating, nor it's eyes in ſeeing; yet there is little reaſon to doubt, that this muſt have been the caſe. It is ſurpriſing too, that an animal, which had continued ſo long without moving, *ſhould* have the capacity of uſing *it's feet, and know* how to uſe them.

Of nutriment the animal would have little or no need, probably, in ſuch a ſituation. As in moſt of the inſtances there was no room for any thing to be diſſipated, no freſh ſupply would be wanting. The trees too, in which the toads were found, could not be deficient in moiſture while green.

CHAP. XXIX.

THE MONK'S GHOST.



THERE are few of my readers, I ſuppoſe, who have not heard of ghoſts and apparitions: though as knowledge is more generally diffuſed, and people are become leſs *ſuperſtitious*, ſtories of this kind are by no

ns ſo frequent as formerly. Some of the
ances, that have been related, have exiſted
in the lively imaginations of timid
ple; or have been abſolute fictions,
ned for ſiniſter purpoſes. Others have
n real, but without any thing ſuper-
ural in them. The ſight and hearing are
two moſt uſeful of our ſenſes, but at the
e time moſt liable to be deceived, parti-
arly the ſight. The circumſtance I am
ut to relate would, no doubt, have ter-
ed an ignorant and ſuperſtitious man, and
bably have circulated as a true narrative
an apparition: happily it occurred to a
n free from ſuperſtition, and well ſkilled
natural philoſophy.

Mr. Schmidt, mathematical teacher at the
ool of Pforte, near Naumburg, which had
merly been a cloiſter, once happened to
ake ſuddenly, as the morning began to
wn. On opening his eyes, he beheld
th aſtoniſhment a monk, ſtanding at the
t of his bed. Looking at him ſtedfaſtly,
appeared to be well fed; and his head, far
m ſmall, was ſunk a little between a pair
very broad ſhoulders. The chamber was
ficiently ſecured; Mr. Schmidt alone ſlept

in it; and he was very certain, that no would attempt to put a trick upon hin jest. He knew, also, that no part of clothes, or any thing else, was hanging his bed's foot. The figure exactly res bled that of a monk, clothed in a w surplice, the falling folds of which were clearly to be distinguished.

Had an ignorant and timid man bel this appearance, he would probably have vered himself up with the bed clothes, firmly maintained, that the ghost of a m had appeared to him. As the school had merly been a cloister, many monks had b buried both in the church and church-y and it was currently reported among vulgar, that the place was haunted. A such an evidence, therefore, the report wo have been considered as true beyond controversy.

Mr. Schmidt, however, was neither ig rant nor timid, and he immediately con tured, that his eyes were deceived, tho he could not imagine in what manner. raised himself up a little in his bed, but *apparition* did not move, he only saw so *what* more of it, and the folds of the

lice were ſtill more conſpicuous. After a ttle while he moved toward the right, yet ne apparition remained, and he ſeemed to ave in part a ſide view of it; but as ſoon s he had moved his head ſo far as to have ſlight glimpſe of the bed's foot, the apparition retreated backward, though ſtill with it's ace to the bed. Following the apparition uickly with his eyes, it retreated with peed, ſwelled as it retreated to a gigantic orm, a ruſtling noiſe was heard, and—— at nce the apparition was changed into the gohic window with white curtains, which was ppoſite the bed's foot, and about ſix or ſeven eet diſtant from it.

Several times after this Mr. Schmidt ndeavoured, when he awoke, to ſee the ame appearance, but to no purpoſe, he window always looking like a window nly. Some weeks after, however, on waking, as day began to dawn, he again erceived the monk's apparition at his ed's foot. Being now aware what occaſioned it, he examined it narrowly. The great arch of the window formed the monk's ſhoulders; a ſmaller arch in the centre of *his, his head*; and the curtains, the fur-

plice. The folds of thefe appeared ı ftronger, than they did at the fame dift by daylight. Thus the figure of the n appeared plainer, nearer, and fmaller, than window would have done.

But you will afk, why did it appear ı To this queftion, by the help of the cut, fhall probably be able to give you a fat. factory anfwer.

Let the eye of the obferver be at O.. M Schmidt himfelf confeffes, that he is fome what nearfighted, that is, incapable of diftinguifhing objects plainly at a diftance. Now, fome preffure upon the eye, or probably the moifture collected upon it, or fome other caufe, had brought the eye to fuch a ftate during fleep, that it was capable of diftinct vifion, or feeing objects diftinctly at a greater diftance than ufual. That this was the cafe is clear, becaufe the folds of the curtain appeared more diftinctly than common. Accordingly the object at twelve feet diftance appeared with the fame degree of diftinctnefs as in ordinary cafes at fix feet, and hence Mr. Schmidt conceived the idea of it's being only *fix feet* diftant; for the clearnefs, with which *a object* is feen, is one of the circumftances

by which we judge of the diſtánce, of an object. The angle of viſion, A O B, under which the window was ſeen, undergoing no change, the figure of the monk muſt have been ſeen under the ſame angle, and as it appeared to be at the foot of the bed, it would ſeem to extend only from *a* to *b*, and conſequently to be much ſmaller than the window actually was, probably about the ſize of a man. Thus, as the figure of the window had a conſiderable reſemblance to that of a monk in a ſurplice, the deception in the faint light of dawn was complete.

Still the apparent retreat of the monk, and his growing bigger, as the eye changed it's poſition, remain to be accounted for. Theſe phœnomena, however, are eaſily deducible from the ſame principles: for, as the idea of the ſmallneſs of the figure aroſe from the nearneſs, at which it was ſuppoſed to be, and this proceeded from the unuſual clearneſs, with which it was ſeen; ſo, when the eye began to return to it's uſual ſtate, which was effected perhaps by the change of poſition, or when, by it's being directed to the *foot of the* bed, the window, or figure of

the monk, was ſeen with leſs clearneſs tl the bed's foot, the ſame impreſſion i made upon the eye, as if the figure had treated from the foot of the bed; and the angle of viſion remained the ſame, monk muſt have appeared to grow lar in proportion as he retreated from *a b* A B. At length, when the eye had retur completely to it's former ſtate, the winc appeared as uſual, and thus the phant vaniſhed. The ruſtling noiſe heard at time muſt have been merely accidental, it would have tended more ſtrongly to i preſs the belief of the reality of the app tion on a weak mind.

CHAP. XXX.

SOMETHING MORE ON THE SUBJECT SWINGING.

WILLIAM reminded his father of the p miſe he made him, which we mentio in the 24th chapter, of explaining to l how any one could ſwing himſelf, with being impelled by another perſon. He learned to do it, and wiſhed to know *principle,* on which his proceeding *founded.*

F. "The whole of the art confifts in a fuitable alteration of the centre of gravity. When you fwing yourfelf in a common fwing, or in the pendulum fwing as it might be very aptly termed, what is it you do, to fet it in motion at firft, and gradually to increafe this motion?"

W. "I bend my body alternately backward and forward."

F. "When you bend your body backward, what follows?"

W. "The rope moves a little forward."

F. "And when you bend yourfelf forward?"

W. "The rope moves a little backward."

F. "Now, from what you have already learned refpecting the pendulum, we may eafily deduce an explanation of this."

"At firft the rope hangs perpendicularly in the direction C A, p. 112. The centre of gravity of your body, therefore, is in A. On bending your body backward, the centre of gravity is carried backward, fay to D; will the rope now remain at reft?"

W. "No; for the centre of gravity will defcend to the loweft point A."

F. "Thus a commencement of the motion is made. But will the centre of gravity remain at A, and the motion ſuddenly ceaſe there?"

W. "No; it has already acquired ſome velocity, which will continue it's motion beyond A, in a curve A B, equal to D A."

F. "But when you, or rather your centre of gravity, has reached B, if you bend yourſelf forward, ſo as to carry the centre of gravity ſtill farther from D, as to E for example, what will follow?"

W. "The centre of gravity will deſcend through the curve E A, and aſcend, by the velocity it has acquired, through an equal curve A F.

"Now, I believe I can explain the continuance of the motion very well: for in F I bend myſelf back again, ſo as to carry the centre of gravity beyond F, and have a ſtill longer curve to paſs through in the third ſwing; and when I return, I do the ſame thing."

F. "Very right; and in this manner the curve is made longer and longer: a boy, who is uſed to it, as you know, can ſwing him-

ſelf almoſt through a complete ſemi-circle, ſo as to make his feet touch the cieling of the room in which he ſwings. Yet I would adviſe you not to ſwing yourſelf quite ſo violently, for ſwinging with moderation is leſs dangerous, and affords ſufficient exerciſe: leave violent and hazardous ſwinging to the ruſſians."

W. "Why to the ruſſians."

F. "Becauſe I believe there are no other people ſo extravagantly fond of ſwinging, or rendered ſo expert at it by practice. There is ſcarcely a houſe in Ruſſia without ſuch a ſwing as ours; beſides which there are public ſwings of various kinds, not common among us, in which people of all ranks ſwing "for amuſement."

CHAP. XXXI.

RUSSIAN SWINGS.

W. "WHAT kinds of ſwings have the ruſſians, then?"

F. "I will tell you; and as you have ſome knowledge of the ſcience of mechanics,

a ſhort account of them will be neither unamuſing to you, nor difficult for you to underſtand.

"In the firſt place, our common rope ſwing is univerſally known in Ruſſia.

"Beſide this, there is the *katſchel*, or ordinary ruſſian ſwing, which conſiſts, inſtead of a rope, of a perpendicular pole, moveable on an axis above, and provided with a ſeat at bottom, which is well ſecured, and ſo contrived, that the perſon cannot fall out.

"Before the perſon that is to be ſwung, there is a place for an expert man, who ſets the machine in motion. At firſt the ſwing moves ſlowly, and but a little way; it's velocity gradually increaſes, however, and at length the bold ruſs gives the ſwing ſuch a violent impulſe, that it turns completely round it's axis: a movement that would unqueſtionably appal a perſon unaccuſtomed to it.

"Both theſe belong to the kind of pendulum ſwings. Another kind conſiſts of the wheel, or rotatory ſwings, which revolve circularly round an axis. Theſe are of two ſorts, perpendicular and horizontal.

" The perpendicular rotatory ſwing conſiſts of a ſtrong horizontal axis, through which two pair of long and ſtout beams paſs, forming four arms, at right angles with the axis, and with each other. Each of the arms conſiſts of two beams, between which, at the end, a ſeat is ſuſpended, moveable on an axis, ſo as to preſerve it's perpendicular ſituation, while the arms move round. For the ſake of ſecurity the arms are faſtened to each other with croſs pieces, ſo that the machine altogether does not appear much unlike a large water-wheel of a mill without the felloe and float-boards. The ſeats are ſecured with doors; and when the machine is made ſtrong as it ought to be, it is perfectly free from danger. Each ſeat will hold two or three perſons, but it is neceſſary, that the ſeats oppoſite each other ſhould be nearly on a balance.

" The machinery, by which this ſwing is ſet in motion, conſiſts of a toothed wheel, made of iron, fixed to the axis of the ſwing, and a cog-wheel adapted to it, which is turned round by means of a winch. At firſt it moves ſlowly, and requires ſome exertion; *but when it is* ſet a going, if the weight be

equally diſtributed, it may be kept in
tion with eaſe.

"This kind of ſwing is common in
ſia, Egypt, and ſome other countries, as
as Ruſſia. Some years ago it was well kn
in England by the name of *up-and-do*
but in conſequence of ſome accidents,
the interference of the magiſtrates, it c
into diſuſe. Lately, however, it has b
revived, and made it's appearance as a
velty at ſome of our fairs.

"The horizontal ſwing is ſufficiently
miliar in this country under the name
round-a-bout. It conſiſts of a large wh
ſupported horizontally on a perpendic
axis, with wooden horſes and carts fixed
ternately at certain diſtances on the fell
With us it is a play for children merely, l
in Ruſſia grown people are amuſed by it."

CHAP. XXXII.

THE ROCKING HORSE.

F. "While we are talking of ſwings,
may mention another kind, where the

brating motion is effected by means of a curved foot, or support. Of this sort are the cradle, and the rocking-horse, such as you had when you were a little boy, and which grown persons sometimes use by way of exercise. Have you any wish to consider the movement of the rocking-horse?"

W. "I am always glad to learn any thing, in which you please to instruct me."

F. "We will draw the figure of a rocking-horse, then, risen on it's hind legs. See p. 108. The support is a segment of a circle, A E N, of which C is the centre, and C A, C E, C N, are radii. The support now touches the ground at A. On the horse sits a boy. The centre of gravity of the boy and the horse together is at G. Can the horse remain in this position?"

W. "No, certainly; for the centre of gravity is not supported, as the perpendicular line from the centre of gravity to the ground, G F, does not fall on the point A, on which the support bears."

F. "The consequence of this must be, that the fore part of the horse will descend by moving forward. In doing this every point of the curve A E will touch the ground

one after another, and the middle point of the curve, E, will come to the ground in D. When it has arrived here, where will the centre of gravity be?"

W. " In I, or ſo that D I will be equal to E G."

F. " But now will the centre of gravity be higher or lower than it was before in G?"

W. " It appears as if it were lower."

F. " Do not ſay, *it appears*; we muſt not be ſatisfied with appearances merely. It does, and muſt lie lower, as may be proved geometrically. For D I is equal to E G, as you very properly ſaid juſt now: but E G is leſs that O G, as you have learned geometry enough to know*, ſtill more conſequently muſt it be leſs than F G; ſo that D I muſt neceſſarily be leſs than F G; in other words the centre of gravity muſt be nearer the ground in I than in G.

" You will now be able to proceed with the argument yourſelf."

W. " As the centre of gravity deſcends from G to I, it will aſcend from I to H, for the machine cannot ſuddenly ſtop when the centre of gravity has arrived at I, on ac-

* Euclid, book 3, prop. 7.

count of the velocity it has acquired. From H it will defcend again to I, and thence afcend to G. And in this manner it will go on alternately moving backward and forward."

F. "Thus the motion fhould continue indeed, did not the refiftance of the air, and the friction of the fupport againft the ground, conftantly operate to retard it, fo that the movement of the horfe would foon fubfide into a ftate of reft, if it were left to itfelf. The boy fitting upon it, however, can eafily keep it in motion, by bending his body alternately backward and forward, fo as to alter the fituation of the centre of gravity.

"The point C in this machine always moves in a right light line from C to K, and from K to C.

"If the centre of gravity were in C, the horfe would ftand ftill as readily in the pofition in which it is reprefented in our figure, as in any other, juft as a wheel will ftand equally well on any part of it's circumference. If the centre of gravity were higher than C, the horfe would tumble over. *But* while the centre of gravity re-

mains below C, it will continue to vibrate like a pendulum, as will be obvious to you, from what I have already ſaid."

CHAP. XXXIII.

FRIENDSHIP OF A GOOSE.

You have frequently been told, my dear children, that it is extremely wrong, to hurt or inflict pain on an animal; yet there are many, who do it from mere wantonneſs, without any malicious intention; as they are far from thinking, that a dog, a cat, a butterfly, or a cock-chafer, has a ſenſe of pain, as well as a man. It is ſtill more unpardonable in grown perſons, to beat and abuſe mute beaſts, incapable of expreſſing their feelings by their cries. How often does the brutal carman ill-treat his poor horſe, unable to drag a heavy load over a ſlippery pavement, or up a ſteep hill! How often does the man, whoſe mind ſhould be more enlightened, and feelings leſs blunted, laſh along his jaded beaſt, leſt his dinner *ſhould* be delayed half an hour! Let your

own heart prompt you to treat with compaſſion thoſe dumb animals, which have not the power of ſpeech, to reproach you for your barbarity, and remember what is written, " The righteous man is merciful to his beaſt."

One of the advantages of natural hiſtory is, that in making you intimately acquainted with animals, it tends very powerfully to impreſs upon your minds the juſtice and compaſſion you owe them, of which you are ſo apt to loſe ſight. You will find in the ſtructure of their bodies, their mode of life, their inſtincts, their capacities, their character, and their inclinations, ſo much that is admirable, and often that is noble, as will not fail to make you aſhamed to treat with barbarity, or even to deſpiſe a creature, on which nature has employed ſo much care.

Of late years many authors have appeared as advocates in the cauſe of the brute creation; and, to give more weight to their arguments, have collected a number of examples, which ſet the worth of animals in a conſpicuous light. I will relate a few of thoſe which will probably give you a higher *opinion of* ſome animals, than you have

hitherto entertained; and chiefly ſuch as diſplay nobler qualities of the heart and mind, than men uſually allow to what we call irrational creatures.

The firſt inſtance I ſhall adduce will be that of a ſingular frienſhip between a gooſe and a dog.

At Little-Grove, in Hertfordſhire, was a gooſe of the ſpecies called Canada geeſe, which are fond of roaming at large, and do not like confinement. This gooſe, however, had contracted ſuch a friendſhip for the yard-dog, that ſhe continually kept near his houſe, in which he was chained, quitting it only when ſhe went for food, and the moment ſhe had eaten it, returning to her poſt. Thus ſhe ſat all day by the houſe of her favourite; though ſhe never attempted to go into it, unleſs it rained. If the dog barked, ſhe immediately began to cackle, flew at the perſon with whom ſhe ſuppoſed the dog to be offended, and endeavoured to bite his legs. Sometimes ſhe attempted to partake of the dog's food; but this the dog, who repaid the warmth of her friendſhip with apparent indifference, would not *permit*. When the reſt of the poultry re-

tired to rooſt, ſhe would not quit her dog without compulſion. In the morning, when driven to the field with the others, there was no getting her away from the gate of the court-yard, where ſhe could at leaſt have a ſight of the dog, and before which ſhe would ſit the whole day. At length the owner of the faithful gooſe, reſolved to leave her to follow her own inclinations, and not afflict her by any forcible ſeparation. Being thus at liberty to obey the impulſe of her attachment, ſhe paraded about the yard at night with the dog, while he was on the watch; and in the day, when he took a walk into the village, ſhe accompanied him, ſometimes walking, ſometimes flying, to keep pace with his trot. This extraordinary attachment continued till the dog's death, which happened two years after it had been firſt noticed. During the illneſs of the dog, ſhe never left him, even to procure food, and would probably have been ſtarved, if ſome corn had not been placed in a diſh by the dog's houſe. The whole of the time ſhe ſtaid in the houſe, and would not ſuffer any one to come near it, except the perſon who brought food for the dog and herſelf. The end of

this goofe was melancholy. After the death of the dog, fhe would not leave his houfe for a long time. At length, a dog of nearly the fame fize and colour being procured as his fucceffor, the poor creature, deceived by outward appearance, and fuppofing it to be her old friend, went confidently into the houfe to the dog, who feized her by the neck, and killed her on the fpot.

What renders this hiftory remarkable is, that the friendfhip commenced after the goofe was grown up; that it feemed to be entirely on one fide; and that it was not the effect of habit, but apparently arofe from gratitude and a fentiment of reflection; for it was univerfally believed at the time, that the dog had fortunately been the means of faving the goofe from being devoured by a fox. The goofe, who had probably more than once difcovered traces of the fox, found herfelf fecure under the protection, and in the company of the dog, and voluntarily repaid his fervices in kind, attacking the enemy, to whom the chained dog could only fhow his teeth.

CHAP. XXXIV.

AN EXPERIMENT WITH CORK-BALLS.

Father. "William, get a bit of cork, ıd cut out of it a little ball: in the mean me, Caroline, thread a needle with ſilk, ıd I will ſhow you an amuſing experiıent."

The cork ball was cut out, and Caroline ad ſtrung it on a thread of ſilk.

F. "We will now hang up this ball, ſo hat it may be ſuſpended freely, without ouching any thing. William, take this tick of ſealing-wax, rub it a little with this ›iece of flannel, and then hold it near the ork-ball."

William did as his father told him: the ork-ball moved toward the ſealing-wax, ınd ſtuck to it.

After it had ſtuck to the ſealing-wax a ittle while, William ſeparated them. He then preſented the ſealing-wax to the cork again, and, to his ſurpriſe, inſtead of mov-*ng toward it,* it now retired before it, ſo

that William could drive it from one to another, as he pleafed. Thus it frequ happens, when two people haftily coı what they call a friendfhip for each (after a fhort intimacy they conceive fu averfion, as to fhun each other whe they happen to meet.

"This is very ftrange," faid Wi "what is the reafon of it?"

F. "That it is ftrange, is very true almoft every thing that occurs in natı equally fo; only what we fee daily doɛ excite our wonder. And when it is : *what is the reafon of it?* it is feldom power, to give a folid anfwer. It wou much better, fairly to confefs this, tl fancy we affign a reafon, when we ı give a name to the phenomenon, or e it in words. For example; 'what ma ftone fall to the ground?'—'Gravitɛ you will fay.—'But what is gravitatio 'A power that impels bodies towarc earth.'—Here the word gravitation ex nothing; it is merely a name for thı nomenon of falling or preffure; and you [illegible] to explain it farther, you

"In like manner, why does the cork ball firſt follow the ſealing-wax, then adhere to it, and, after they have been ſeparated, retreat before it? The anſwer is: it is the effect of *electricity*. But the word electricity no more explains this phenomenon, than gravitation does the other; it is merely a term to denote the cauſe of the phenomenon, with which we muſt not imagine ourſelves acquainted, becauſe a word has been framed to expreſs it. We might as well have expreſſed it by x, y, or z, as the algebraiſts do unknown numbers, while they are finding their values *.

"The word electricity has been framed for this purpoſe from *electrum*, the latin

* As few of my young readers, I imagine, know any thing more of algebra than the name, though it is on ſeveral accounts a ſcience of great utility, with which I hope many of them will be acquainted hereafter, I ſhall juſt mention, that it is a kind of arithmetic, in which letters are employed to expreſs numbers; for ſuch numbers as are known, as the three numbers given in the rule of three, the algebraiſt uſes the letters at the beginning of the alphabet; for ſuch as are unknown, as the fourth number, or number ſought, in the rule of three, he uſes the letters at the end.

word for amber, in which the property was firſt diſcovered. But in this caſe, as in others, we cannot do better, than examine and compare the circumſtances with which we are acquainted; that is to ſay, the appearances themſelves, which will find us ſufficient employment; for the alphabet of nature is more extenſive even than that of the chineſe, though happily more amuſing. Accordingly we will vary our experiment a little. Cut out a couple more of cork balls, William.

" Hang one of them up here by a thread; and hang up the other by a narrow ſlip of paper. Now rub your ſealing-wax again, as you did before, and hold it near theſe cork balls: you will ſee a remarkable difference in the phenomena."

William rubbed his ſtick of ſealing-wax, held it near the cork balls, and they appeared to be attracted by it more forcibly, than that which was ſuſpended by the ſilk. Having ſeparated them from the ſealing-wax, he held this near them again; when, inſtead of flying from it, as the former *ball had* done, they were as forcibly attracted

ly it as before. It was exactly the same on a resh repetition of the trial.

F. "Try the effect of a stick of sealing-wax without rubbing it first."

They were neither attracted nor repelled.

F. "And now of this key."

It had no effect upon the balls, either rubbed or unrubbed.

F. "And now of this glass rod."

Here again William found the same phenomena as with the sealing-wax. Without being rubbed the glass rod had no effect: when it was rubbed, it attracted each of the balls; and if that, which was suspended by the silk, were parted from it after they had been together a few moments, it was then repelled by it, while the other two were uniformly attracted by it.

"I do not understand it," said William.

F. "We will vary the experiment again a little, and then see whether we can make any thing of it."

Caroline was desired to string another cork ball upon a thread of silk; and this was hung up at a little distance from the first, that was also suspended by a silken thread.

First each ball was tried with glafs, and with fealing-wax, to fee whether they were acted upon alike.

Then both the glafs rod and the fealing-wax were rubbed, or *electrified:* one of the balls was firft attracted by the glafs, and, after it had been feparated from it, repelled. The fealing-wax was then prefented to it, and immediately it was attracted by it ftrongly, and ftuck to it. Thus the ball, that the glafs repelled, was attracted the more powerfully by the fealing-wax.

On reverfing the experiment, it was juft the fame thing. If the ball were firft attracted by the fealing-wax, and afterward repelled by it, it was then the more forcibly attracted by the glafs rod.

The action of glafs, therefore, and that of fealing-wax, were oppofite to each other.

An experiment was now made with both the balls fufpended by filk.

Firft they were both attracted by the glafs rod; they were then feparated from it; the glafs rod was removed to a diftance, and the balls, thus left to themfelves, mutually *repelled* each other.

It was precisely the same, when both were electrified by means of the sealing-wax.

But when one ball was electrified with the sealing-wax, the other with the glass rod; and they were then left to themselves, they attracted each other.

Little balls of sealing-wax, suspended in the same manner by silken threads, were slightly attracted by a stick of sealing-wax previously rubbed; but they neither attracted nor repelled each other afterward; nor were they repelled by the sealing-wax.

CHAP. XXXV.

CONTINUATION.

Father. " At first sight these experiments seem tolerably puzzling; but we will try, whether they will not lead us to some notions, that may contribute toward their explanation.

" Sealing-wax and glass, when rubbed, exhibited marks of electricity: iron did not, either with or without rubbing.

" Thus we find there are bodies, in which native electricity may be excited, and others, in which it cannot. Hence the former are called *electrics*; the latter, *non-electrics*. Among the former are glaſs, ſealing-wax, amber, pitch, ſulphur, ſilk, &c. Among the latter, metals, water, paper, green wood, &c.

" The cork balls ſuſpended by ſilken threads, after being touched by an excited electric, exhibited an electric property, which the electric had imparted to them; but the balls of ſealing-wax did not.

" Electricity may be diſtinguiſhed, therefore, into *native* and *communicated*. Bodies which exhibit the former do not receive the latter; and, on the contrary, no native electricity can be excited by rubbing in thoſe, to which electricity may be communicated from others.

" The cork balls exhibited this communicated electricity, when they were ſuſpended by ſilken threads; but not when ſuſpended by a flaxen thread, or a ſlip of paper. The ſilk, therefore, appeared to confine the electricity communicated to the balls, ſo that it could not eſcape from them; the other

ſubſtances, on the contrary, to give a paſſage to it.

"Hence we may diſtinguiſh bodies which do not conduct electricity, *non-conductors*, and bodies which do, *conductors*. Bodies that are *electric per ſe*, as glaſs, ſealing-wax, ſilk, &c. are non-conductors, as appears in ſome meaſure from our little experiments: the non-electrics, as metals, waters, &c. are conductors of electricity. A non-electric body, when ſeparated from other non-electrics by means of an electric body, or non-conductor, is ſaid to be *inſulated*. Thus the cork ball was inſulated by the ſilken thread, ſo that the electricity imparted to it could not eſcape.

"When electricity had been communicated to the inſulated cork balls from ſealing-wax, the native electricity of ſealing-wax repelled them: ſo when it was communicated to them from the glaſs, they were repelled by the glaſs. On the other hand, when they were electrified by the ſealing-wax, they were repelled by the glaſs, and the contrary.

"Hence we are naturally led to infer, *that there* are two oppoſite kinds of elec

tricity, which mutually attract each ot
These we may call the *vitreous* electric
and the *resinous*; or, as they appear
have opposite powers, *positive* and *nega*
The little experiments abovementioned
close to us the following grand law, whic
confirmed by all that have hitherto b
made.

"*Similar electricities repel each oth
opposite electricities attract.*

"Thus when the two insulated cork l
were both electrified by glass, or by seal
wax, they repelled each other. When
was electrified by glass, the other by seal
wax, they attracted each other.

"It is in consequence of the same
that light bodies are first attracted by
rubbed sealing-wax, and then repelled
it.

"Burn this little bit of paper to ash
rub the stick of sealing-wax, and hold it
them. See how the little light ashes are
attracted by the sealing-wax, and then
pelled by it. As soon as they have recei
electricity from the sealing-wax, the sim
electricities of the sealing-wax and a

repel each other, so that the ashes are driven off from the sealing-wax.

"Now cut out a couple of little puppets of thin paper, Caroline: you shall see how prettily they will dance about."

Caroline cut out the puppets, laid them upon the table, and held over them the stick of sealing-wax previously rubbed. Immediately they rose up, and danced about, or stood upon their feet, and bent toward this side or that, according as the sealing-wax was moved.

F. "Now can you explain these phenomena from the law I mentioned above?"

W. "In some measure; yet I do not clearly comprehend the reason of the first attraction. The law says, opposite electricities attract each other; but the cork balls, or paper ashes, before the sealing-wax has touched them, have no electricity, so that here the law seems to me not to apply."

F. "You are very right; yet we may suppose the case to be thus. Both kinds of electricity are present in all bodies; but as they have a strong attraction, or, as chemists say, a strong affinity to each other in *their natural* state, they are intimately

united, and *saturate* each other; that is, they are united in such proportions, that the powers of the one balance the powers of the other. Thus neither of the electricities is at liberty to exert it's powers; so that a body, in which the two electricities are united, or in equilibrium, will exhibit no appearance of electricity; and in this state are the cork balls at first.

"But when this equilibrium is destroyed in the sealing-wax by rubbing it, and one of the kinds of electricity, the negative, is thus set free; this is capable of exerting it's effects on those bodies, that are within it's *sphere of action*.

"Thus, when the cork ball is within this sphere of action, the negative electricity of the sealing-wax repels the negative electricity, that was before in the cork ball in a state of equilibrium, and attracts the positive, by means of which the ball itself, which is very light and moveable, is attracted."

W. "But then the repulsion of the negative electricity should repel the ball at the *same time*, and thus one effect counterbalance the other.

F. "Your objection is very proper. Yet, if all bodies in their natural ſtate contain a portion of both kinds of electricity, the difference between conductors and non-conductors muſt conſiſt rather in the degree of their capacity for conducting electricity, than in perfectly oppoſite ſtates. Hence the cork ball, we may preſume, is not ſo perfectly inſulated by the ſilk, but that it's negative electricity may paſs more eaſily along it, than the poſitive can through the air, which is a very bad conductor, particularly when dry, for it differs much in this reſpect, according as it is dry or moiſt.

"Thus when the cork ball is not inſulated, the attraction is more powerful, as you obſerved in the ball ſuſpended to the flaxen thread; as in this caſe the negative electricity finds a freer paſſage out of the ball, and leaves the poſitive more at liberty, to be attracted by the negative of the ſealing wax.

"There is another mode of accounting for it, by ſuppoſing the attractive power of the oppoſite electricities to act with more force, than the repulſive power of ſimilar electricities. Both theſe ſuppoſitions, how

ever, you will confider merely as what they are, hypothefes; for neither of them is perfectly fatisfactory. At prefent, indeed, though we are acquainted with many effects of electricity, we have but a very fuperficial knowledge of the nature of this truly wonderful power, the action of which is unqueftionably of very great extent and importance in natural phenomena: by purfuing our inveftigation of thefe, we may hereafter attain more clear and folid ideas of it.

"For to-day this may fuffice: fome other time I will fhow you many more pleafing experiments in this beautiful and amufing branch of natural philofophy."

CHAP. XXXVI.

FILIAL AFFECTION OF TWO YOUNG RATS.

I HAVE already related an anecdote of the friendfhip fhown by a goofe toward a dog; but the following ftory exhibits a ftill nobler *fentiment* in animals, which are commonly *abhorred* by us. That in the brute creation

mothers have great love for their young, and will even facrifice themfelves in their defence, is well known, and deferves our admiration; but the following inftance of filial affection, and the gratitude of young animals toward a parent, is much more to be admired.

Mr. Jofeph Purdew, lying abed one morning reading, had his attention called off from his book by a noife, refembling that of rats climbing up a wainfcot. The noife ceafed for a moment, and was renewed again. His bed was but at a little diftance from the fide of the room, and he narrowly obferved the place, from which the noife feemed to come. It was not long before he faw a rat make his appearance at a hole, without any noife, look cautioufly all around him, and after a little while withdraw. Prefently the rat came again, with a large old rat, which he led by holding it's ear in his mouth. With them came a fecond young rat. The two young rats left the old one at the mouth of the hole, ran about the room picking up the crumbs, which had fallen from the table the preceding evening at fupper, and carried them to the old one. Mr. Purdew, aftonifhed at this attention in fuch animals, perceived, that the old

rat was blind, and could only find the cru the young ones brought by feeling abou them. When this affecting ſcene had co nued a little while, ſome perſon came the room. As ſoon as the young rats h the noiſe, they gave the old one intima of it by a cry, and did not endeavou eſcape themſelves, till the old one had entered the hole, into which they follc him.

What think you of this fact, my yc readers? Did not theſe animals exhibit a tern of filial affection, ſufficient to put m: who pride themſelves in the poſſeſſioı reaſon, to the bluſh? How often do we f that parents, who have done every thin their power for their children, and deı themſelves not only pleaſures, but even neceſſaries of life, the better to educate th are deemed a burden by thoſe very child when they are grown old and infirm, either totally neglected by them, or po and grudgingly maintained! May none you ever be liable to this ſhameful reproa but think of the good young rats, that *their* blind and aged parent.

CHAP. XXXVII.

HISTORY OF A WILD GIRL.

How much reaſon have you, my young readers, to thank Providence, for having cauſed you to be born and brought up among civilized men; for what would you have been, had you, bereft of parental care, and left to yourſelves, grown up remote from human ſociety! It is through the means of ſociety alone, that we become human creatures. Even the ſavages, as they are called, of America and the South-Sea iſlands, live together in ſociety; and in conſequence are not wild, they are only leſs poliſhed than europeans. Do you wiſh to know what man would become, if deprived of human ſociety, and uneducated by his fellow men, you may learn it from the following account of a wild girl, which is well worth your reading.

In the year 1731, as a nobleman was ſhooting, at Songi, near Chalons, in Champagne, he ſaw ſomething at a diſtance in the water, which he took for a couple of birds, and at which he fired. The ſuppoſed birds

avoided the ſhot by diving inſtantly unde the water, and, riſing at another place, mad to the ſhore, when it appeared, that the were two children, about nine or ten years c age. They carried aſhore with them ſever fiſhes, which they tore in pieces with thei fore-teeth, and ſwallowed without chewing As they were going from the ſhore, one c them found a roſary, probably dropped b ſome traveller, at which ſhe teſtified grea joy, by ſcreaming and jumping about. I order to keep it to herſelf, ſhe covered it witl her hand; but her companion, who per ceived this, gave her ſuch a blow upon th hand with a ſort of club, that ſhe could no move it. With her other hand, however ſhe ſtruck her companion in return ſuch a blow upon the head, with a ſimilar club, a brought her to the ground, with a louc ſhriek. The victor made herſelf a bracelet with the roſary; but ſhe had ſtill ſo much pity on her companion, that ſhe covered her wound with the ſkin of a fiſh, which ſhe ſtripped off, and bound it up with a ſlip of the bark of a tree. They then parted. The girl that had been wounded returned to the river, and was never after ſeen; the other went to th

village of Songi. The ignorant inhabitants were frightened at her ſingular appearance, for her colour was black, and ſhe had on a ſcanty covering of rags, and ſkins of animals. They ſet a great dog at her: but ſhe waited his attack, without ſtirring from her place, and, as ſoon as he was within reach, gave him ſuch a blow on the head with her club, as laid him dead on the ſpot. Unable to gain admiſſion into any houſe, for every door was ſhut againſt her, ſhe returned into the fields, climbed up a tree, and there took her repoſe.

The viſcount d'Epinoy, who was then at his ſeat at Songi, offered a reward to any one, who could catch this wild girl. As it was ſuppoſed ſhe would be thirſty, a bucket of water was placed under the tree, to entice her down. On awaking, ſhe looked cautiouſly around, came down, and drank; but immediately aſcended to the ſummit of the tree, as if ſhe thought herſelf not otherwiſe ſecure. At length ſhe was allured to come down by a woman, who walked under the tree with a child in her arms, and offered her fiſh and roots. When ſhe had deſcended, *ſome perſons* lying in wait ſeized her, and

conveyed her to the viscount's seat. At first she was taken into the kitchen, where she fell upon some wild fowl, and ate them up, before the cook missed them. A rabbit being offered her, she immediately stripped off the skin, and devoured the flesh.

An opportunity of observing her with more ease was now obtained, and it was found, that the black colour of her skin was accidental; for after she had been repeatedly washed, her naturally fair complexion appeared. Her hands were upon the whole well-formed, only the fingers, and the thumb in particular, were uncommonly strong, which no doubt was ascribable to her frequently climbing trees, as she would swing herself from one to another like a squirrel.

The viscount d'Epinoy delivered her into the care of a shepherd, recommending to him to be extremely attentive to her, under a promise of paying him well for his trouble. On account of her wildness she was commonly known by the name of the shepherd's beast. It cost a great deal of trouble, to render her a little tame. She was very dexterous at making holes in the walls or roof and would creep through an aperture so small

that an eye-witneſs could not conceive how it was poſſible. Once ſhe eloped in a ſevere froſt, during a heavy fall of ſnow, and after a long ſearch was found ſitting on a tree in the open fields.

Nothing was more aſtoniſhing than the ſwiftneſs and agility, with which ſhe ran. Though latterly long illneſs and want of exerciſe diminiſhed her ſpeed, it was always ſurpriſing. She did not take long ſteps like other people, but her run was rather a *flying trip*, which was more like gliding than walking. Her feet moved with ſuch quickneſs, that their motion was ſcarcely diſcernible. Several years after ſhe had been caught, ſhe was capable of outſtripping wild animals, as ſhe proved to the queen of Poland in 1737: for, being taken out on a hunting party, ſhe ran after rabbits and hares that were ſtarted, caught them preſently, and brought them to the queen.

The quickneſs of her eye was equally aſtoniſhing. In a moment ſhe could look every way round her, with ſcarcely turning her head, which was very neceſſary for her ſecurity, and procuring her food, in her wild *ſtate.*

Both the girls uſed to ſpend their nights on trees. They laid down on a bough, held themſelves faſt with one hand, and reſted their heads on the other. In this ſituation, according to our maiden's account, they ſlept very ſoundly.

In her ſavage ſtate ſhe had no language, but a ſort of wild ſcream, which ſounded frightfully when ſhe was in anger, and particularly when a ſtranger attempted to take hold of her. Long afterwards her ſpeech had ſomething wild, abrupt, and childiſh; but when ſhe was a little civilized, ſhe appeared to be a quick lively girl.

There was nothing, from which ſhe was more difficult to be weaned, than eating fleſh and vegetables raw. Her ſtomach could not bear dreſſed victuals, ſo that ſhe fell into one diſeaſe after another, though raw food was allowed her occaſionally. Perhaps the change was attempted with too little caution. At firſt ſhe was led by this propenſity to play ſome laughable tricks. Once the viſcount had a great deal of company, and ſhe ſat at table with them. None of the thoroughly dreſſed and high-ſeaſoned diſhes being to her taſte, ſhe ſtarted up, vaniſhed like lightning

filled her apron with live frogs from the neareſt pool, haſtened back, and beſtowed them among the gueſts with a liberal hand, joyfully exclaiming, as ſhe diſtributed her agreeable preſent, "here, here, take ſome!" It is eaſy to imagine how the company were delighted with the frogs hopping all over the plates and diſhes, while the little wild girl, aſtoniſhed at the ſlight eſtimation in which they ſeemed to hold her delicious morſels, buſied herſelf in catching the frogs that leaped about the floor, and replacing them on the table.

In the year 1732, this remarkable maiden was baptized by the name of Maria le Blanc. On account of the change in her mode of life ſhe was often ill, and, after the death of her patron, ſpent the remainder of her days in a convent.

How this child came into that wild ſtate, and in what country ſhe was born, were circumſtances, that could never be known with certainty. It was conjectured, however, that ſhe was by birth an eſquimaux, and brought to Europe in ſome ſhip; for, when ſhe had learned to talk, ſhe ſaid, that ſhe had twice *croſſed the* ſea; gave a deſcription of boats,

resembling those of the esquimaux; and once, when she was shown a series of delineations of people of different countries, she seemed agreeably surprised on coming to that, in which the esquimaux were represented.

CHAP. XXXVIII.

OTHER INSTANCES OF WILD BOYS AND GIRLS.

AMONG all the instances we have of wild persons, the preceding is one of the most remarkable: it may not be amiss, however, to give a concise account of a few more.

In the year 1661, a boy apparently about nine years old was found in a forest in Lithuania, among the bears. He was well-made, and his countenance was pleasing, but he was extremely wild. It proved impossible to tame him, and accustom him to the clothing or food of civilized men.

In 1694, a young man of twenty was *found* among a herd of bears, in Lithuania *likewise*, on the frontiers of Russia. He is

to have been all over hairy, and to have :ed on both hands and feet. He difplayed few marks of reafon, had not a human e, and was difficult to tame: by degrees, ever, he learned to ftand upright againft all, eat common food, and to fpeak a e, though in a hoarfe and fcarcely intelli- e manner. He could not recollect any g, that had befallen him in his wild ftate.

n 1717, a wild girl of nineteen was caught Zwoll, in Oberyffel. She had been loft ier parents, when only fixteen months old. fkin was brown, hard, and hairy: the of her head, long and thick: her fpeech, uncommon ftuttering: her food, in her l ftate, green herbs, and leaves of trees. walked erect: wore an apron of ftraw, ch fhe had made herfelf: was very fhy, difficult to be taken: but foon became iliarized to fociety, and learned to talk to fpin.

n the year 1719, two wild boys were ght on the Pyrenees, where they fkipped ut from rock to rock like the chamois.

While we are on this fubject we muft by means omit to mention Peter the wild as he was commonly called. This boy

was found in the woods near Hamelen, in Hanover, when his majeſty George I was hunting, in the year 1725. He was ſuppoſed to be then about twelve years of age, and had ſubſiſted in thoſe woods upon the bark of trees, leaves, berries, &c. for ſome conſiderable length of time. How long he had continued in this ſtate, indeed, is uncertain: but that he had formerly been under the care of ſome perſon, was evident from the remains of a ſhirt-collar about his neck, when he was found. In the following year he was brought to England; and great pains were taken, to inſtruct him: but he could never be taught to articulate any words, except his own name, Peter, and that of king George. He learned to hum a few ſimple tunes, however; and was ſo delighted with muſic, that, if he heard any one play on an inſtrument, he would dance and caper about, till he was nearly exhauſted with fatigue. He was likewiſe made to underſtand every thing that was ſaid to him, reſpecting the common affairs of life. In his nature he was gentle and timid, ſo that he would ſuffer himſelf to be governed by a *child*; yet he was ſubject to the paſſions of anger, joy, &c. Upon the approach of bad

weather he always appeared ſullen and uneaſy; and at particular ſeaſons of the year he had a ſtrong propenſity for ſtealing into the woods, where he would feed eagerly upon leaves, beech-maſt, acorns, and the green bark of trees; but if he rambled far from home, he could not find his way back again.

Peter was about five feet three inches high, in his countenance there was nothing ugly or diſagreeable, and he retained a freſh healthy look in his old age. He died in february, 1785, when he was ſuppoſed to be about ſeventy-two years old.

CHAP. XXXIX.

SOME OBSERVATIONS ON CHYMICAL AFFINITY, SOLUTION, AND CRYSTALLIZATION.

"You are going to ſhow us ſomething curious again to-day, father!" ſaid Caroline, as ſhe perceived upon her father's table the microſcope, through which ſhe had ſeen with ſo much aſtoniſhment the animalcules of *infuſion*.

F. "I am: and I ſhall do it with a great deal of pleaſure, as there is no amuſement more innocent, than what we derive from the contemplation of nature. It gives me much ſatisfaction, therefore, to find you have a taſte for ſuch amuſements. A few days ago, the microſcope exhibited to you ſwarms of living creatures: by way of change you ſhall now ſee inanimate objects, yet not leſs wonderful."

"What are they?" exclaimed William and Caroline, with eager expectation.

F. "You ſhall obſerve the proceſs of *cryſtallization* in *ſolutions* of ſalts."

William and Caroline had never before heard theſe technical terms, or, if they had heard them, had no clear ideas of their ſignification. Mr. Goodwyn had often told them, that, on all occaſions, they ſhould endeavour to obtain as clear ideas as poſſible of the things ſignified by words; and whenever they heard any, which they did not underſtand, ſhould aſk him to explain their meaning. He was perſuaded, likewiſe, and had found by experience, that technical terms, *though* generally conſidered as puzzling, are *in fact more* eaſy to be underſtood: and the

eafon is obvious: common words are gene-ally ufed in a loofer fenfe, and frequently vith feveral different meanings, while tech-ical terms have ufually one precife fignifica-ion only. Accordingly, William requefted in explanation of the terms *folution* and *cryf-tallization.*

F. " I will endeavour to fatisfy you in this refpect, if you will be attentive. Obferve, I throw fome of this falt into this glafs of water. At firft you fee the particles of falt, as they were when dry: but they do not con-tinue fo long, they gradually diminifh: I ftir it; you fee no more falt in a folid form, the water only looks a little turbid: when it has ftood a minute or two, it will be quite clear. —See, there is now nothing in the glafs ap-parently but clear water: yet the tafte will convince you, that there muft be a great deal of falt in it. Tafte it, William."

W. " It taftes falt, indeed."

F. " Here then we have a fluid, that con-tains another fubftance, the component parts of which are equally invifible to the naked eye and the beft magnifying glafs. The con-nexion between the minuteft particles of the fubftance, that was at firft vifibly mixed with

it, is loosed; these particles are intimately united with the particles of the water, and they are no longer distinguishable from each other. The whole is become an uniform substance, different from what either was before. Such a substance formed by the intimate union of two or more substances, is called a *solution*. The process by which they are united is called *dissolution*; and the solid substance is said to be *dissolved* in the fluid, which is called the *solvent*, or *menstruum*. As the change is most apparent in the solid, the fluid is commonly considered as the active substance; and this idea is confirmed by our applying an active expression to the fluid, and a passive to the solid. But there is little room to doubt, that a mutual action takes place between them; for in some cases the solid seems to exert the active power."

W. "But what is the reason, that the particles of the salt unite so intimately with the particles of the water?"

F. "That is a question, to which it is not in my power to give you a satisfactory answer. Here, as in many other natural *phenomena*, I must remind you of the expression of the great Haller, who zealously

pursued the study of nature, and, feeling the narrow limits of the human understanding, exclaimed:

'’Tis not for mortal mind to penetrate into the secret recesses of nature.'

"All that we can say, which in fact is no more than expressing the phenomena in words, is, the particles of the water, and the particles of the salt, in a certain *temperature*, that is, in a certain degree of warmth, have a stronger attraction for each other, than that by which the particles of the salt are held together. Thus the cohesion between the particles of the salt, which rendered it a solid substance, is destroyed by a stronger power. Substances that have this attraction for each other are said to have an *affinity*, or *chymical affinity*. The degree of this affinity varies, it being stronger between some substances than others. Hence, if we add to a solution a third substance, which has a stronger affinity for either of the two that compose the solution, than these two have for each other, these will separate, and that which has the strongest affinity for the substance added will unite *with it*, leaving the other in it's former *state*. *This* is called *elective* attraction.

this elective attraction take place between the ſubſtance added and the fluid of the ſolution, the ſolid before diſſolved in it ſubſides to the bottom. This proceſs is named *precipitation*; the matter at the bottom of the veſſel is called a *precipitate*, and is ſaid to be *precipitated* from the fluid, in which it was diſſolved, by the ſubſtance added."

C. " Will you let us ſee an example of it, father?"

F. " Willingly. Fetch me a bit of chalk, a little vinegar, and ſome pearl-aſhes, and we will make the experiment."

CHAP. XL.

SOLUTION AND PRECIPITATION.

CAROLINE having fetched the things ſhe was deſired from the kitchen, the chalk was put into the vinegar, in which it diſſolved, ſo that nothing more of it was to be ſeen. Some pearl-aſhes were then added to the ſolution, which became turbid, and the chalk gradually ſubſided to the bottom in the form of a white powder.

F. "This experiment, I preſume, you can explain without difficulty."

W. "The vinegar, in which the chalk was firſt diſſolved, has a ſtronger affinity for the pearl-aſhes, than for the chalk, and in conſequence quits the chalk, to unite with the pearl-aſhes."

F. "Right. But now tell me, do you ſuppoſe, that ſolid or dry ſubſtances can diſſolve one another?"

W. "I ſhould think not."

F. "In this you think juſtly; for in every ſolution it is requiſite, that one of the ſubſtances be in a fluid ſtate. It is not neceſſary, however, that either ſhould be fluid by nature: you may reduce one or both of them to a ſtate of fluidity by means of heat, in other words, you may melt them, and then they would be capable of forming a ſolution. This is called a ſolution *in the dry way*, to diſtinguiſh it from the caſe where one or both of the ſubſtances are naturally fluid, which is called a ſolution *in the moiſt way.*

"Thus, for example, ſolutions of ſalt, ſugar, or gum in water, of chalk in vinegar, of reſins in ſpirit of wine, and of ſilver in *aqua fortis*, are called ſolutions in the moiſt

way. So alſo is that ſolution which takes place between two fluids, as water and vinous ſpirit; though this is commonly called a mixture, but improperly, for here an intimate union, or proper chymical combination takes place, wherefore it ſhould be expreſſed by the term ſolution.

"Solutions in the dry way are ſuch as of wax in melted lard, tin and lead melted together, &c.

"Precipitation likewiſe is diſtinguiſhed in the ſame manner. Thus it is called a precipitation in the moiſt way, when the ſolution is naturally fluid, as in the experiment we juſt now made with the chalk and vinegar; and a precipitation in the dry way, when the ſolution muſt be rendered fluid by fire, as of lead in ſulphur, called galena, which being melted, the addition of an alkali; for which the ſulphur has a ſtronger affinity, will precipitate the lead."

W. "If I remember right, you ſaid at firſt, there were ſolutions conſiſting of more than two ſubſtances: but in the inſtances you have given, the ſolutions have contained only two, and when a third was added, one

of them was precipitated, and only two remained diſſolved."

F. "Examples of more compound ſolutions are not difficult to find: ſuch as ſugar, water, and vinous ſpirit, which form a ſolution of three ingredients; or common ſalt, ſalt-petre, and water; and in the dry way, lead, tin, and biſmuth, or gold, ſilver, and copper; with many others."

C. "There is one thing I would aſk; can we diſſolve as much of one of the ſubſtances in the other, of ſalt in water for inſtance, as we pleaſe?"

F. "In ſome caſes in the dry way we can; but not in the moiſt. A certain quantity of a fluid, as you ſeem to imagine, can diſſolve only a certain quantity of a ſolid. When the fluid has diſſolved as much of the ſolid as it can, it is ſaid to be *ſaturated* with it; and if more of the ſolid be added, this will remain at the bottom of the veſſel undiſſolved.

"The proportions, in which different ſubſtances are ſoluble in others, vary, and depend in ſome meaſure on the temperature of *the ſolvent.* Thus a given quantity of water will diſſolve more of ſugar than of alum

and boiling water will diſſolve more of either than cold; though, on the ntrary, cold water will diſſolve more mag than hot. It is alſo to be remarked, th er, after it is ſaturated with one ſalt, is ſtill capable of diſſolving a certain quantity of another.

"It is a ſingular circumſtance too, that a conſiderable quantity of ſalt may be diſſolved in water, without the water's riſing perceptibly higher in the veſſel, in which it ſtands; the ſpace, that the two ſubſtances occupy after ſolution, not being equal to that they both occupied when ſeparate."

CHAP. XLI.

CRYSTALLIZATION.

Father. "As I have now given you ſome inſight into what is moſt important concerning ſolution, I may proceed to explain to you briefly what is meant by cryſtallization.

"The particles of many ſubſtances have a diſpoſition, in paſſing from a fluid to a *ſolid* ſtate, to arrange themſelves in regular

figures. This is called cryſtallizing. Thus the freezing of water is a true cryſtallization, of which we frequently ſee beautiful ſpecimens on our windows in winter mornings. So, likewiſe, if part of the water of a ſaturated ſolution of any ſalt be evaporated, ſo much of the ſalt, as the remaining water cannot keep diſſolved, will return to a ſolid ſtate, and in doing this, cryſtallize. You ſhall ſee an inſtance of it in the ſalt we diſſolved juſt now."

The microſcope was now adjuſted, ſo that the light fell properly on the ſlide, on which a tolerably large drop of the ſolution of ſalt was put. William and Caroline looked in by turns. At firſt nothing but a clear fluid was viſible. Preſently Caroline perceived a ſmall tranſparent ſolid point in it, which appeared no larger than a ſmall grain of ſand, though the microſcope magnified the diameter of an object two hundred times. More ſuch points ſoon formed in different parts of the drop, but firſt round the edge.

"Obſerve theſe points attentively," ſaid Mr. Goodwyn; "they are the commencement of cryſtallization, the firſt combination *of the component* particles of the ſalt, at

leaſt as far as we can diſcern, that were diſſolved in the water, and are now ſet free from it. You will ſoon perceive a change in them."

In fact, it was not long before our young obſervers ſaw ſquares of different ſizes, as regular as a geometrician could have drawn, form around theſe points. From the point, as a centre, proceeded ſtraight ſlender lines to the corners of the ſquare, croſſing each other at right angles, and other ſlender lines, parallel to theſe, filled up the intervals. It was a pleaſing ſight. Now here, now there, a new ſquare aroſe; the largeſt in the middle of the drop. Here and there other figures leſs regular appeared; probably becauſe the particles of ſalt were prevented from aſſuming their proper form by ſome obſtacle. At length the field of the microſcope was completely beſtrewed with ſuch figures; no more freſh ones appeared; and, when the ſlide was withdrawn, nothing but the dry ſalt was ſeen on the glaſs.

William and Caroline were ſo much amuſed, that they deſired to examine another drop, which exhibited juſt the ſame appearances.

As uſual, William was ready with his old

queſtion, which is as eaſily put, as it is commonly difficult to anſwer: "What is the cauſe of this?"

F. "Of the primary cauſe we know no more in this caſe, than we do in many others. The component parts of ſubſtances have a diſpoſition to unite firmly together, or an *attractive* power for each other. This power is in great meaſure counteracted by a certain degree of heat in quickſilver, water, and melted metals; and by the attractive power of the menſtruum in ſolutions. If the degree of heat be diminiſhed in the former inſtances, the component parts of the ſubſtances will unite into a ſolid. The ſame thing will take place in ſolutions, either by cooling, or by diminiſhing the quantity of the fluid menſtruum, while that of the ſolid diſſolved remains the ſame, or by the addition of a third ſubſtance.

"I have ſaid it may be effected in ſolutions by cooling, which is the caſe with ſuch ſubſtances as are ſoluble in greater quantity in a hot menſtruum than in a cold. Of this we have an inſtance in ſaltpetre, which diſſolves in much greater quantity in hot water than in cold; ſo that if you ſaturate

boiling water with ſaltpetre, and then let it cool, a conſiderable portion of it will ſhoot into cryſtals, in much the ſame manner as ice in a veſſel of water when it freezes.

"The experiment, that we have juſt made with the ſalt and water, or brine, is an example of the ſecond mode. The water in the drop upon the ſlide evaporated by degrees, ſo that the remaining water became leſs and leſs capable of holding all the ſalt in ſolution, and in conſequence the particles of the ſalt gradually united together. What you here ſaw in miniature is executed on a larger ſcale in ſalterns, or ſalt-works. In theſe the brine of a ſalt ſpring, as at Namptwich and Northwich in Cheſhire, and Droitwich in Worceſterſhire, or ſea-water, as on various parts of our coaſts, is conducted into large pans, under which a fire is kept, which evaporates the water, and the particles of ſalt unite into cubic cryſtals. Common ſalt will not cryſtallize by cooling like ſaltpetre, for hot water diſſolves very little, if any, more of it, than cold; indeed it cryſtallizes beſt when the water is kept pretty hot.

"In the laſt mode the cryſtallization is effected by the addition of a ſubſtance, which

has a ſtronger affinity for the ſolvent. Thus, for example, cryſtallization is effected in a ſolution of ſalt, by the addition of ſpirit of wine. In this caſe, however, the cryſtals are ſmaller, and not ſo regular, of which I will give you the reaſon. When particles are obliged to unite ſuddenly, they cannot unite in ſuch regular order, or in ſuch large bodies, as when they are attracted toward each other ſlowly and gradually. When ſpirit of wine is poured into a ſolution of ſalt, it combines quickly with the water, ſo that the ſalt is as quickly ſet free to unite; which does not happen when it is left to unite by gradual evaporation, or cooling; and the more ſlowly either of theſe takes place, the larger and handſomer will be the cryſtals produced.

"Salts, ſuch as ſaltpetre, common ſalt, and the like, ſhow a peculiar diſpoſition to cryſtallize: and hence ſome have imagined, that every cryſtallization muſt be a ſalt, and require a ſolution in the moiſt way. But this is an erroneous opinion: for cryſtals are formed in the dry way, as in melted metals, and glaſs, when very ſlowly cooled, and without the preſence of any ſalt, as in pure water that freezes. Cryſtallization

however, requires, that the particles be in a ſtate to move freely; whence it is moſt perfect in liquid ſolutions, and much leſs ſo in metals, the fluidity of which, when melted, is always inferior. Even the fume, or ſmoke, that aſcends from certain bodies, aſſumes particular figures, where it attaches itſelf."

W. "Laſt night, by candle-light, I ſaw ſomething like a little black worm floating in the air, which ſettled on my paper. At firſt I thought it was ſomething alive; but when I found it was not, I bruſhed it off, and it left a black mark on the paper, and on my finger. Was it ſmoke, that had united into ſuch a body in the air?"

F. "Certainly; and it is a very frequent appearance, when we burn candles that emit much ſmoke.—But to return to our cryſtals, did you ever obſerve the little grains of ſalt with attention?"

C. "O yes; I have often obſerved them: they commonly look like little ſquare funnels, cloſe at the point."

F. "Very true; and larger in ſome ſalt, ſmaller in other. Theſe little funnels are the groundwork of cubical cryſtals, ſix of them uniting by their points, and the hol-

ows of the funnels being filled up by additional matter.

" The cryſtals of every kind of ſalt have their particular figure, ſalts varying greatly from each other in this reſpect, as we ſhall hereafter have ſome other opportunity of obſerving. But to enable them to retain this figure, it is always neceſſary, that a certain portion of water ſhould be united with the particles of the ſalt. This is called the *water of cryſtallization*; and if it be expelled from the cryſtals by heat, theſe loſe their cryſtalline form, and fall into a dry powder, which, however, retains all the properties of the ſalt."

CHAP. XLII.

NATURAL SALT-PANS.

Father. " I juſt now obſerved to you, that what you had obſerved in miniature was performed in an extenſive way in the preparation of ſalt. This, however, requires proper buildings and implements, which cannot be erected and provided without conſi-

derable expenſe. You ſee ſalt on the table daily; but you little imagine what buildings muſt be erected, veſſels and implements procured, fuel expended, and labour employed, before we can obtain it in the form in which we have it for uſe.

"Yet there are countries, where theſe are not requiſite, nature performing the whole proceſs. Hollow places in the low grounds there anſwer the purpoſe of our large and expenſive pans; while the air and the ſun perform the office of evaporating the brine, for which we are obliged to employ much labour and fuel, before we can bring the ſalt to cryſtallize."

Caroline. "Where are thoſe countries?"

F. "At the Cape of Good-Hope. You know where that is."

C. "Yes; it is the ſouthern extremity of Africa, where the dutch had a ſettlement, which we took from them in the beginning of the preſent war with them."

F. "At the Cape of Good-Hope, as we are informed by Dr. Thunberg, who has given a valuable deſcription of that country in his travels, there are large places, or na-

ural ſalt-pans, in which a great deal of brine ollects during the rainy ſeaſon."

C. "Is there a particular rainy ſeaſon here, then?"

F. "Yes; but of that another time.

"The water of this brine gradually evaporates, and leaves behind good ſalt, which he people of the country collect for their uſe. In this manner they are ſupplied by nature with all the ſalt they want, without he leaſt aſſiſtance from art.

"When the rainy ſeaſon is over, a very briſk evaporation of the water enſues, occaſioned partly by the great heat of the ſun, partly by the violent winds. The ſalt then cryſtallizes, and falls to the bottom. The cryſtallization takes place moſt powerfully in november and december, and in the middle of the day, from ten o'clock to three. During this time the ſalt may be ſeen forming a kind of pellicle, or thin ſkin, on the ſurface of the water, before it becomes ſo heavy as to ſink to the bottom. The ſalt produced in this way is very fine, and the cryſtals are driven to the north-weſt ſide of the pool by the blowing of the ſouth-eaſt wind, where they muſt be immediately collected. If this

be not done, the salt accumulates, and falls to the bottom in layers, or flakes, from which a coarser kind of salt is formed, in larger grains, and mixed with impurities, which give it a grayish colour. This salt is used only to preserve meat, or flesh; the finer or whiter salt is employed for the table, and for salting butter.

"Some of these natural salt-pans are so large, that it will take half an hour to walk round them; and when they are covered with salt, they resemble a lake frozen over, which has a singular appearance in the summer, and in such a climate.

"These pools are often at a distance from the sea, and at considerable heights. Their water has no connexion with that of the ocean, but is produced entirely by the rain, which falls in the spring, and evaporates in the summer. The soil every where abounds with salt: accordingly the rain, which flows down from the higher grounds, dissolves this salt, and carries it along with it, till it arrives at a hollow: there it stops, and gradually evaporates, till it is so diminished, that crystallization follows."

CHAP. XLIII.

THE SPINNING-WHEEL.

IONG other female occupations, Caroline
ately learned to ufe a fpinning-wheel,
1 had been prefented to her by her god-
er, and was diligently employed at it,
her father came in.

Do you know," faid Mr. Goodwyn,
looking attentively at his daughter's
ftry, " how it is, that the thread winds
your hand upon the bobbin?"

iroline. " You are laughing at me now,
r. Do not I fee how fwiftly the flyer
s round with the bobbin? how then
the thread avoid being wound upon

ather. " You think, it cannot. Well,
the flyer out with the bobbin, and
them round with your hand; or,
:h is better, take the ftring that paffes
the pulley of the bobbin, and place it
re the other is, that paffes over the pul-
of the *flyer*. Now you perceive, when
turn the wheel, both the flyer and the

bobbin go round as ſwiftly as before; but does the thread wind upon the bobbin?"

C. "No; it does not!"

F. "Beſides, if the thread wound up as ſwiftly as the bobbin turns round, do you think your fingers could draw out the flax, and unite it into a thread, ſufficiently faſt?"

C. "Why, no; I cannot ſpin ſo faſt as that; and ſo the thread would be for ever breaking, particularly when I ſtop a few moments, as I frequently muſt, when there are unevenneſſes in the flax, to correct the thread."

F. "You ſee, therefore, if this were the caſe, you muſt ſpin much more in an hour than you poſſibly can with all your diligence, and that the bobbin muſt be much ſooner full."

C. "It appears ſo, indeed: but how is it, then, that the thread does wind round the bobbin?"

F. "That is the very queſtion which you thought at firſt ſo ſimple. In the firſt place, the ſtring that turns round the bobbin and flyer is double; one ſtring paſſing over the pulley of the flyer, the other over the pulley of the bobbin. If you put both on th

lley of the flyer, the thread will not be ɪund up. Farther, the bobbin, you know, moveable round the axis of the flyer, and ı turn independently of it. If both go ınd equally faſt, the thread will not wind ınd the bobbin."

C. "I think now I underſtand ſomething it. The bobbin muſt turn round faſter in the flyer, and this muſt be effected by ans of the ſtring paſſing round it. Am I ht?"

F. "Perfectly: and you will readily conive, that, if the bobbin turn round in the ne direction as the flyer, but a little more iftly, the thread, which paſſes through is ſtaple of the flyer muſt wind round the bbin."

C. "That I comprehend very well."

F. "To underſtand it the better, we will ake a mark with chalk on the wheel, the bbin, and the flyer. I will now turn the eel round ſlowly once, and do you obſerve w often the flyer goes round in the mean ile."

C. "Six times."

F. "*Now obſerve how often the bobbin s round during one turn of the wheel.*"

C. "Seven times."

F. "Thus, then, as the bobbin makes one more turn than the flyer in every turn of the wheel, the thread muſt wind once round the bobbin every time the wheel goes round."

C. "True: now the whole is clear."

F. "The whole! let us ſee. What neceſſity is there, to make the flyer turn round ſo ſwiftly? The machine might have been ſo contrived, that the bobbin and wheel ſhould go round together, and the thread wind round it in a ſimilar manner; or the wheel might be turned round more ſlowly, and the thread ſuffered to wind up on the circumference of the wheel itſelf."

C. "But that would not be ſo convenient."

F. "Very likely. This, however, is not the only reaſon. Beſide the convenience to the ſpinner, the bobbin is neceſſary for twiſting the thread properly, and ſmoothing it's ſurface by friction."

C. "Still what is the reaſon, that the bobbin goes round oftener than the flyer, ſince they are both turned by the ſame wheel?"

F. "Your queſtion ſhows, that you re-ect on the ſubject. You will readily un-erſtand, that the flyer muſt move round ſix imes, while the wheel moves round once, ecauſe the circumference of it's pulley, over which the ſtring paſſes, is equal only to a xth part of the circumference of the wheel. 'or, as the ſtring is ſtrained tight both upon he wheel and the pulley, when the wheel urns once round it carries with it as much f the ſtring as is equal to the circumference f the wheel, or ſix times the circumfe-ence of the pulley, ſo that it muſt conſe-ently turn the pulley round ſix times."

C. "I underſtand that clearly."

F. "Now, if you look at the pulley of he bobbin, over which the other ſtring aſſes, you will perceive it is ſomewhat maller: in your's it is equal to a ſeventh art of the circumference of the wheel, and onſequently the bobbin goes round ſeven imes while the wheel makes one turn."

C. "I did not think, that the turner had o much to conſider and reflect upon, when e made a ſpinning-wheel."

F. "In fact he reflects very little. 'urners make theſe uſeful implements, juſt

as other mechanics make their violins, harpſichords, and indeed almoſt every thing, according to the rules they learned from their maſters in their apprenticeſhip, and the meaſures they were once taught, without troubling themſelves about the principles, on which they are conſtructed. Hence theſe are not always followed as they ought; and in many caſes there is room for improving moſt implements, if their makers poſſeſſed more theoretical knowledge. The honour of reflection belongs almoſt excluſively to inventors and improvers. Thus we are indebted for the invention of the common ſpinning-wheel to a german, of the name of Juergens, who lived at Brunſwic near three hundred years ago; and this ingenious machinery, that moves the bobbin backward and forward, without which it would be neceſſary to be frequently ſhifting the thread from one ſtaple on the flyer to another, to the great interruption of the work, and danger of breaking the thread, was lately invented by Mr. Antis, of Fulneck, near Leeds, for which a premium was beſtowed on him by the Society for the promotion of arts and commerce."

C. "I shall now be still fonder of my spinning-wheel, since you have taught me to understand it: but for this instruction, I might have continued spinning all my life, perhaps, without once thinking what I was actually about."

F. "One more question, however: as you are so diligent, how much can you spin in an hour?"

C. "My mother tells me, that I shall soon be able to spin about five skeins of thread."

F. "That is a hundred and fifty yards; for the reel is a yard in circumference, and each skein is thirty rounds of the reel."

C. "That is a great deal."

F. "Yet you would spin a great deal more, if the thread wound once round the bobbin every time you turned the wheel round. Let us suppose, that your foot depresses the treadle twice in a second, and that the circumference of the bobbin is only two inches, in this case four inches of thread would be wound upon it every second, and sixty times four, or 240 inches, in every minute. But 240 inches are twenty feet, which would be 1200 feet, or 400 yards in an hour."

C. "Then I ſhall not ſpin half ſo much as I ought to do, according to your calculation."

F. "Very true: and the reaſon is, no doubt, that an expert ſpinner cannot form the thread ſo faſt as the bobbin goes round. She checks the thread, to alter places where it runs uneven, and the like; this does not occur at regular periods; and thus the bobbin runs ſometimes ſlower than it does at other times, but always faſter than the flyer. Hence you ſee how neceſſary it is, for the bobbin to have a ſeparate motion of it's own.

"You have now enough of the theory, ſo go on with your practice."

CHAP. XLIV.

OF BEAMS AND PLANKS.

WILLIAM one day ſeeing a large beam conveying along the road on a timber-carriage, was ſurpriſed to obſerve, that it bent. "*I did* not think," ſaid he, "that ſuch a *thick beam* would bend."

"Yet it is very natural," anſwered his father: "the thickeſt beam can bend as well as the ſlighteſt lath; it depends entirely on the proportion of the weight to the ſtrength of the body. If you conſider the thickneſs of the beam, you will find, that the weight of the part which lies behind the axletree cannot be ſmall. How much do you ſuppoſe the weight may be, that acts upon the unſupported end?"

William. "I do not know."

F. "Let us endeavour to eſtimate it. It is good to acquire an accuracy of eye in our youth, and indeed of touch and ear, which may be done by frequent practice. If we often compare unknown lengths, breadths, thickneſſes, and heights, at different diſtances from the eye, with things of which we already know the dimenſions, we ſhall ſoon be able to judge with tolerable accuracy the length, breadth, or height of a room, a building, or the like. So of weights; if we frequently take a known weight of one, two, or more ounces, or pounds, and remark the degree of exertion it requires to ſupport it, which is commonly called poiſing it, we

ſhall ſoon acquire a readineſs at eſtimating the weights of things."

W. " But we cannot apply this to very large bodies, ſuch as this beam for inſtance."

F. " True: yet here we may call in the aſſiſtance of the eye. Thus I ſhould ſuppoſe the end of the beam to project ten feet beyond the axle tree, and to be a foot broad, and a foot thick: conſequently to contain ten cubic feet. Now oak is nearly of the ſame ſpecific gravity with water, and I know, that a cubic foot of water weighs 62 pounds and a half. The weight therefore muſt be, if we reckon the cubic foot of oak two pounds and a half lighter than a cubic foot of water?

W. " Ten times 60 pounds, or 600 pounds in the whole. And this weight, from what you taught me ſome time ago on the ſubject of the lever, muſt be equally divided between the two ends, ſo that the unſupported end is depreſſed by a weight of 300 pounds."

F. " Very juſt: and this weight may readily be preſumed ſufficient, to overcome the *coheſion of* the particles of the wood in a

ſmall degree, ſo as to occaſion a perceptible bending in a length of ten feet.

" It may not be amiſs to obſerve to you on the preſent occaſion, that the bending of a piece of timber frequently depends much on the poſition, in which it is placed. The beam before us is ſquare, ſo that it matters not on which ſide it lies: but in a plank, which is much broader than it is thick, the caſe is very different. You have often ſeen a carpenter carrying planks upon his ſhoulder, and muſt have obſerved, that they bend a great deal when laid flat; on the contrary, if they be laid edgewiſe, their weight is not ſufficient to bend them perceptibly in that direction, though then the motion of carrying them along will make them bend from ſide to ſide. Builders are well acquainted with this principle; and as it is of importance to them, to prevent, as much as poſſible, the timbers of a houſe from bending, I will ſome day go with you to a houſe that is building, and deſire the carpenter to point out to you the ingenious methods, that have been deviſed for this purpoſe."

CHAP. XLV.

HOW TO WEIGH A BEAM WITHOUT A STEELYARD OR SCALES.

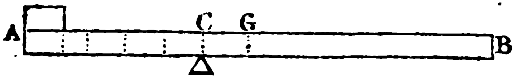
Father. " We juſt now eſtimated the weight of the beam, by gueſſing at it's contents in cubic feet, and multiplying theſe by the weight of one cubic foot of the timber: but could we not find the weight of the beam in ſome other way?"

William. " By a very large ſteelyard."

F. " True; we might do it in that manner without difficulty; and there are ſteelyards, in many places, large enough to weigh a loaded waggon. But is it not to be done without any ſuch help?"

W. " I cannot tell how."

F. " There is no ſuch great difficulty in it. Draw the following figure.



Let A B be the beam, and G it's centre of *gravity*. Now if the beam reſted on a ſup-

port at it's centre of gravity, the two ends would be in equilibrium, or balance each other. But if the support were on one side of the centre of gravity, as at C, the longer end, B, would sink to the ground. To restore it's equilibrium, a weight must be placed at A; and from the weight required, and it's distance, with that of the centre of gravity, from the point of support, the weight of the beam may be calculated. Perhaps you could make the calculation yourself, recollecting the law, that the powers will be in the inverse proportion of their distances from the point of support when they are in equilibrio."

W. "Since we may consider the weight of the beam as lying in the centre of gravity G, we may say, as C G is to C A, so is the weight A to the weight at G, or the whole weight of the beam."

F. "Suppose, then, that A C is five times the length of C G, and we are obliged to place exactly a hundred weight at A to produce an equilibrium, what will be the weight of the beam?"

W. "Five hundred weight."

F. " Hence we may deduce another mode of eſtimating the weight of a beam. Suppoſe I have attained by experience a knowledge of the exertion it requires for me to lift one, two, or three hundred weight from the ground. Now if the beam be lying on the earth, and I put a rope round one end, for the convenience of lifting it, taking it for granted, that the beam is not too heavy for this, could I not in this manner eſtimate the weight of the beam?"

W. " O yes: for as the end A reſts on the ground, while the end B is raiſed, it is a lever of the ſecond order, and as the beam is of the ſame ſize throughout, the power is as far again from the point of reſt as the weight, ſo that the weight muſt be double the power."

F. " Accordingly, if the exertion I employ, to raiſe the end B, appear to me equal to what it would require to lift two hundred weight and a half, I may infer, that the beam muſt be about five hundred weight."

CHAP. XLVI.

HOW MEN STAND.

WHETHER a body be ſecure from falling, or not, depends upon the ſituation of it's centre of gravity.

In every ſtanding body the centre of gravity muſt lie over ſome part of the ſurface upon which it ſtands, ſo that a line drawn perpendicular to the centre of gravity muſt fall within the limits of that ſurface. Thus, for example, a man cannot ſtand ſteady, unleſs a line let fall perpendicularly from between his hips, where his centre of gravity lies, touch the ground ſomewhere within the ſpace of which his two feet form the boundary.

Hence it is obvious, that a quadruped, which has four feet, as a horſe, muſt ſtand firmer than a biped, which has but two, as a man. A body may ſtand in an inclined poſture, and yet ſteadily, if the perpendicular let fall from the centre of gravity be not without the limits of the ſurface on which it ſtands. A man may incline himſelf forwards

backwards, or to either ſide, without falling, and without moving his feet; and the farther his feet are from each other in the direction in which he inclines himſelf, the greater this inclination may be.

Thus a man ſtands firmer when his feet are at a moderate diſtance from each other forwards and ſideways at the ſame time, as in what dancing-maſters call the fourth poſition, than when the feet are near together.

My young readers, no doubt, have already learned at the dancing-ſchool, that they muſt turn out their toes, to ſtand gracefully. But turning out the toes in a moderate degree is not graceful merely, it is conducive to firmneſs of poſture; for by this a man is rendered leſs liable to loſe his equilibrium ſideways, than if he turn his toes inwards, or place his feet parallel to each other, which is a faulty poſition according to the laws of mechanics, as well as the rules of dancing. Still, to turn the toes out too much is alſo faulty, and many dancing maſters carry this too far. It is ungraceful; for what can be graceful, that is unnatural? Man's natural mode of walking is forwards; in doing which, however, he is to guard againſt falling on

either ſide. Accordingly nature has placed his feet in this direction, at the ſame time that ſhe has given him muſcles at the hips, which are capable of turning the whole leg, with the foot, ſomewhat outwards, and inwards alſo if it be neceſſary: but to turn them ſo far round, as to bring the heels as forward as the toes, cannot be done without a conſtrained action of the muſcles, and a contorſion of the whole limb. A man walking forwards with his toes pointing directly to each ſide would appear a ridiculous figure to any one of uncorrupted taſte, who had never ſeen ſuch an exhibition before. This turning out of the toes too much is to be reprobated on account of it's inſecurity alſo; for in conſequence of it a man is liable, to loſe his equilibrium either backward or forward. The rules of dancing and mechanics ſhould go hand in hand, otherwiſe the former muſt be defective: the latter never can, for they are the laws of nature.

The nearer the centre of gravity is to the ſurface that ſupports it, the leſs danger there is of it's being carried beyond this ſurface; and this is one reaſon why a man ſtands *firmer with bent knees*, as he does when h

expects any ſhock or thruſt. But the chief advantage of this poſture is, that a man can readily ſhift the ſituation of his centre of gravity, as the occaſion may require; for which reaſon it is neceſſary, that he do not lower the centre of gravity ſo much, as to hinder the free action of his limbs. A man who ſhould ſtand in a boat under ſail, a carriage going along, or like one of Mr. Aſtley's pupils on a galloping horſe, would act very imprudently, if he endeavoured to keep his legs ſtraight, with a ſtiff knee. In ſome corporal exerciſes, where it is neceſſary to ſtand firm againſt external force, as in fencing and wreſtling, the poſition with bended knees, which the rules of art preſcribe, is founded therefore on ſolid principles.

CHAP. XLVII.

AMUSING EXPERIMENTS RELATIVE TO THE CENTRE OF GRAVITY IN MEN.

MY young readers may derive ſome amuſement from the following experiments relative to the centre of gravity.

1. *To ſeat a perſon ſo, that he cannot riſe up.*

Seat the perſon in a chair, ſo that his body ſhall be erect, his thighs in a horizontal poſition, and his legs perpendicular; and require him to riſe up, without inclining his body forward, or his feet backward. Now, let him exert himſelf as much as he pleaſes, he will find it impracticable: for in this poſition his centre of gravity will be perpendicularly over his ſeat, and, if he would raiſe himſelf, the thighs act as two levers, bearing the weight of the body on their extremities at the hips, the knees form the fulcrum, and the moving power reſides in the muſcles, that extend the legs and thighs; but theſe, in ſuch a poſition, act too obliquely, and their diſtance from the fulcrum is too little, for them to overcome the weight.

This is an experiment of conſiderable antiquity, for it is mentioned by Ariſtotle.

2. *To place a man ſo, that he cannot ſtand on one of his legs only.*

Place him with his ſide againſt a wall, ſo that the whole leg, on which he is to ſtand, ſhall touch the wall from the foot to the hip, and in this poſture he will be unable, to raiſ

his other foot from the ground, ſince the moment he does ſo his centre of gravity will be unſupported, and he muſt fall.

3. *To place a perſon in a poſture, in which he cannot take any thing from the ground juſt before his feet.*

Let him ſtand with his back againſt a wall, ſo that his heels ſhall touch it, and every attempt he makes to bend forward, to reach the object before his feet, he will be in danger of falling, as his centre of gravity is unſupported. It muſt be made a condition, however, that he ſhall not bend his knees. That he muſt not lay hold of any thing with his hand, to ſupport himſelf, is a matter of courſe.

4. *At how great a diſtance can a man reach, to take up any thing from the ground?*

If a perſon ſtand freely on the open ground, with his feet cloſe together, and his knees ſtraight, he will not be able to take up a piece of money, or the like, that lies on the ground about two feet before him. With bended knees he can reach ſomewhat farther, without loſing his equilibrium. To take up any thing, that is on one ſide of him, he muſt incline the lower part of the body a little

backwards. If this be rendered impracticable, as by placing him with his back againſt a wall, as in the preceding inſtance, he cannot reach any thing ſideways, even though cloſe to his feet, without raiſing the oppoſite foot up into the air.

CHAP. XLVIII.

SOME TOYS CONSTRUCTED ON THE PRINCIPLE OF THE CENTRE OF GRAVITY.

1. *The poſture maſter.*

Few of my readers, I preſume, are unacquainted with the toy ſold by this name. It is made of the pith of elder, with a bit of lead at the bottom. As the weight of the lead is conſiderable, compared with that of ſo light a ſubſtance as the pith of elder, the centre of gravity of the toy is in the leaden foot. Accordingly, if you incline the figure on one ſide, to the right for inſtance, the centre of gravity is unſupported it is true, yet it is not removed to the right hand beyond the point where the foot of the figure

ſtill touches the ground, but remains ſtill on the left hand; ſo that the foot will fall back into it's former poſition, and the figure reaſſume it's erect poſture, as ſoon as the force you employed to incline it is removed.

2. *A cylinder that rolls ſpontaneouſly up hill.*

Make a hollow cylinder of paſteboard, and faſten a narrow piece of lead on the inſide in the direction of it's axis, or make a cylinder of light wood, and run a little melted lead into a hole near the circumference at one end, or at both. If ſuch a cylinder be laid on an inclined plane, with the lead uppermoſt, but ſo as to be a little nearer the riſing ſide of the plane, as the lead, in which the centre of gravity of the cylinder lies, ſinks downwards, the cylinder will aſcend up the inclined plane, till the lead becomes lowermoſt, which may be when the cylinder has rolled up a ſpace nearly equal to half it's circumference.

A clock, to point out the time of the day, has been conſtructed on this principle.

3. *A double cone which rolls (or rather appears to roll) up hill.*

A piece of wood is to be turned in the ſhape of two cones joined together at their baſes. For this a ſtand is made, conſiſting of two pieces of wood, meeting at one end in an acute angle, and ſupported by three legs, in ſuch a manner, that the angular point is lower than the oppoſite part of the ſtand. Thus the ſtand is an inclined plane, down which round bodies uſually roll. But the double cone takes an oppoſite direction: for, if you place it at the angle of the ſtand, the ſides are ſo cloſe, that it muſt reſt on the part where it is thickeſt; and conſequently it's centre of gravity, which is in the middle of the axis, will be nearly half the thickneſs of the baſe above the ſupport. On the other hand, though the ſides of the ſtand are higher as their diſtance from the angle increaſes, they are more remote from each other, ſo that the cone can ſink deeper between them, whence it's centre of gravity lies lower in fact at the upper end of the ſtand than at the lower end. Thus the cone rolls from the point of the angle toward the baſe, ſo that it appears to aſcend up hill.

The leſs acute the angle of the ſtand, the *aſter the cone* will roll: but there are three

circumſtances, that affect it's motion: 1ſt, the angle of the ſtand; 2dly, the inclination which the plane of the ſtand makes with the horizon; 3dly, the angle which the ſides of the cone make with it's axis. Theſe three magnitudes ſhould be in due proportion to each other. How this proportion is to be aſcertained my readers will learn hereafter, if they purſue their mathematical ſtudies.

CHAP. XLIX.

OTHER TOYS OF A SIMILAR KIND.

4. *The little ſawyer.*

This well-known toy conſiſts of a wooden figure of a man holding before him with both hands a frame-ſaw, which, near the lower end, paſſes through a piece of timber, glued faſt to it at right angles. On that end of the timber, which paſſes behind the man, a leaden ball is fixed. If this figure be ſet on it's feet on the edge of a table, under which the timber paſſes freely, it will be preſerved in equilibrio by the leaden ball; and if you give it's head a gentle puſh, it

will move backward and forward, as if ſawing, and continue this motion ſome time. The leaden ball may be diſpenſed with, if the timber be made of ſufficient length and weight.

The following is the principle, on which this toy is conſtructed. The centre of gravity of the whole figure, with the ſaw and leaden ball, lies under the feet of the puppet, ſo that it cannot fall, as long as thoſe feet form the point of ſupport; and when it is made to incline either way, the centre of gravity is raiſed and carried to one ſide of the perpendicular from the point of ſuſpenſion, to which it muſt deſcend as a *pendulum* does, continuing to vibrate in a ſimilar manner.

5. *The little rope-dancer.*

A puppet is made of wood, holding in it's hands, inſtead of a rope-dancer's pole, a ſemicircular wire, the ends of which are turned downward, and reach below the feet of the puppet. Each end of the wire is loaded with a leaden ball, ſo that the centre of gravity falls under one of the feet of the figure, the other being carried backwards and raiſed in the air. This puppet will ſtand ſecurely

on one foot on a thread ſtretched horizontally, and balance itſelf like a rope-dancer. If the thread be ſtretched obliquely, it will ſlide down, ſtill preſerving it's equilibrium.

6. *To hang a bottle of water on a little ſtick reſting unconfined on the edge of a table.*

Round the neck of the bottle, or handle if it have one, tie a ſtring ſufficiently ſtrong, with a loop of ſuch a length, that the ſtick, when paſſed through it, and reſting on the mouth of the bottle, ſhall form with the bottle an acute angle. If the ſtick be placed ſo as to be ſecure from ſlipping, when it reſts upon the table, the greater part of the bottle will hang obliquely underneath it; and thus their common centre of gravity will lie underneath the point of ſuſpenſion.

7. *The tumbler.*

This is a little puppet of wood, the body of which is made crooked in the ſhape of an S, hollow, and divided into two cavities by means of a tranſverſe piece of wood, in which however there is a hole, to form a communication between the two. In one of theſe cavities is contained a little quickſilver, which can readily paſs from one to the other through

the hole. The arms are moveable round an axis, which paſſes through the breaſt, and have a pulley at the ſhoulder, to which a ſilk thread is faſtened, that paſſes under the clothes, and is made faſt at the other end to the leg. Both the arms and legs muſt be made tolerably long, the better to balance the body.

If this figure be placed on the upper ſtep of a ſtair made for it, ſo that the head lies lower than the belly, the quickſilver will run out of the cavity of the abdomen into that of the thorax, the head will incline downward, and the figure will ſtand on it's hands.

By this motion of the arms the ſilk thread is ſtretched, and draws over the legs, ſo that theſe, with the lower part of the body, acquire a preponderance, and the figure, turning over, arrives at the ſecond ſtep on it's feet. The quickſilver now runs out of the thorax into the abdomen, whence the belly, in conſequence of the curvature of the figure, is thrown forward. The arms and upper part of the body then gain the preponderance, ſo that the figure turns over again; and in this manner it deſcends all the ſteps.

This ingenious toy muſt be made with great nicety, to ſucceed well. It is ſaid to be a chineſe invention: and though only a plaything for children, it's mechaniſm well deſerves to be examined by my young readers, when they have an opportunity; as a mere deſcription, which is all that can be given here, may not be ſufficient to impart a complete idea of it.

CHAP. L.

TWO MORE PROGNOSTICATORS OF WEATHER.

In chapters xxv and xxvi animals have been mentioned, which prognoſticate changes in the weather with tolerable certainty, and to theſe the two following may be added.

The thorny loach is one of theſe. The other ſpecies of the loach are very good eating, but this is tough and inſipid. It is about a foot in length, as big as the manured reed, or large reed ſometimes uſed for fiſhing-rods, and is ſlippery like an eel. This fiſh is kept in a large glaſs bottle full of water, with

two fingers depth of ſand at the bottom. As long as the weather is ſettled, it remains quiet on the ſand, and the water is clear: but if bad weather be coming on, it is reſtleſs, and winds itſelf about from place to place; after which rain, or wind, in general ſoon follows. If a heavy ſtorm, or thunder, be approaching, it appears ſtill more reſtleſs, and ſometimes aſcends to the top, as though it felt itſelf confined, and would creep out of the neck of the bottle, ſometimes plunges into the ſand, and wallows about in it, ſo as to render the water turbid, and itſelf inviſible. This ſingular preſenſion of a change in the weather it frequently diſplays four and twenty hours before it takes place.

To preſerve this fiſh alive, the water muſt be changed frequently, and ſome crumbs of bread thrown into it.

Another prognoſticator of weather is the leech, an animal found in ponds and ditches, and often of conſiderable utility to man.

This animal is very tenacious of life, ſo that, if it be cut in two, the parts thus ſeparate will continue to move about in the water for ſeveral days, or even weeks. Here, *however*, let me intreat my young readers

never to make experiments on any thing that has life, out of caprice, or premature curiosity. When physicians, or natural philosophers, inflict pain on animals, they do it, either to discover in them properties, that may be of utility to man, or to extend our knowledge of nature. And even this is not to be done wantonly: the end, that the philosopher proposes to himself, should be important; he should be careful, to make his experiments with all the tenderness possible, inflicting pain as little as may be; and he should never repeat them unnecessarily. No one of a feeling mind can reflect on the superfluous and reiterated barbarities of a Spallanzani, and some others, without horrour. Unless for some important purpose, which children cannot have in view, the cruelty of mutilating or wounding a living creature, depriving it of the air necessary to it's existence, or even keeping it in confinement, is inexcusable. Though the mute animal cannot cry out for help, do not it's eager and convulsive movements tell you, that it feels pain, that it pants for life and liberty? Say not, to excuse your cruelty toward an irrational animal, that it has less sensibility, and

feels lefs pain than a man would feel. How know you the degree of pain, of which an animal is fufceptible? Does not this very quality, of which we are talking, that of perceiving an approaching change in the weather, tend, with many others, to fhow, that the nerves of animals poffefs great fenfibility?

To return from this digreffion, the leech, of which we were fpeaking, is frequently employed inftead of the fcarificator and cupping-glafs by the phyfician. It is very greedy of blood, readily fixing on any animal, the fkin of which is capable of being pierced by the inftrument with which it is furnifhed for the purpofe, and fucking it's blood, till it is completely diftended with it. When a pond, or ditch, in which leeches are, is emptied, they frequently faften on the naked legs of the labourers, from which they are not to be difengaged without violence, unlefs you fprinkle a little falt on them, which will make them drop off without rifk of any injury to the part.

If you would employ the leech as an indicator of the weather, you muft keep it in a glafs veffel partly filled with water. It

ferene fettled weather it lies on the b curled up like a fnake. If rain be c on, it afcends to the furface of the and remains there, till the weather be; clear up. Againft wind it fwims abo great agility, and does not ceafe it's ments, till the wind begins to blow. a thunderftorm is approaching, it r fome days out of the water, feems 1 and is convulfed. Throughout the wi lies curled up at the bottom of the and takes it's winter fleep: but if it be to fnow, or thaw, it afcends to the 1 of the veffel. In general it remains bottom of the veffel in warm weather, top in cold.

Once a week in fummer, and once a night in winter, the leech fhould have water, with fome fand, and a little b

CHAP. LI.

SOME EXPERIMENTS ON VIS INERTIÆ, AND THE COMMUNICATION OF MOTION.

THERE is a moral, and there is a phyſical averſion to motion, or rather to a change of ſtate. In ſome languages, from their general reſemblance, they are called by one common name; though they are not ſo with us. The phyſical quality we call *inertia*, or *vis inertiæ:* the moral, from which I would hope my young readers are free, *ſluggiſhneſs*, or *indolence*. The phyſical we all poſſeſs, however lively and active we may be. When from a ſtate of reſt we would ſet our bodies in motion, they require a certain degree of force, and a certain ſpace of time, proportionate to the weight of our bodies, juſt as much as a ſtone or a log of wood would do. In like manner, when our bodies are once ſet in motion, time and force are requiſite to bring them to a ſtate of reſt; ſo that, were it not for the kind attraction of our parent earth, we could not venture to take a leap

within doors, as we ſhould daſh our heads againſt the cieling; or in the open air, left we ſhould fly Heaven knows whither. This phyſical inertia, however, is a beneficial quality; and ſo is the moral, when it does not degenerate into abuſe; but we muſt be careful, not to counteract it ſuddenly: it is with this, as with obſtinacy; each yields to gentleneſs, while violence may be employed in vain.

When a boy is ſeated on a cart without a back, if they, who are to draw or puſh him along, ſet the vehicle in motion ſuddenly, the rider, unleſs he holds faſt with his hands, inevitably falls backward. If there be a back to the cart, the back of the rider will ſtrike againſt it. Why is this? The anſwer is, becauſe the communication of motion requires time. The motion is communicated firſt to the part in contact with the ſeat, becauſe of the friction between them, while the upper part of the body lags behind. Thus the centre of gravity is thrown behind the ſurface of ſupport, and the body comes backward to the ground, with the legs commonly raiſed in the air, as theſe cannot ſo ſpeedily change their poſition with reſpect to

the rest of the body, the occurrence being unexpected. If the friction against the seat be trifling, and the pull be very sudden, the seat will slip from under the rider, and he will come to the ground on his bottom.

If the motion be commenced slowly, and increased gradually, there will be time for it's communication, and the rider will retain his seat in safety.

When the motion is suddenly checked, the reverse takes place. As soon as a boat, that is sailing or rowing to land, touches the shore, every person in her is thrown forward. If a person in such a case be standing, his feet will be suddenly stopped with the boat, on account of the friction between them, while the motion of the upper part of the body will continue, so that he must fall, unless he advance one of his feet, or take the precaution to move his body backwards at the right time.

It is the same when a coach or other carriage is suddenly stopped, when a galloping horse stops short unexpectedly, and in other similar cases.

CHAP. LII.

MORE CURIOUS EXPERIMENTS ON THE SAME SUBJECT.

The houſe-maid, when the handle of her hair-broom is looſe, reverſes it, and ſtrikes the end of the handle three or four times ſmartly againſt the ground. Why does ſhe ſo? She has ſeen others do the ſame, and knows by experience, that it will faſten the handle, though ſhe does not know the reaſon. The fact is, the quick motion of the handle is ſuddenly ſtopped, but the head of the broom, which is looſe, continues in motion ſomewhat longer, and thus gets farther upon the handle, till it is ſtopped by it's tightneſs.

If you hold a ſand-box in one hand, and ſtrike upon it with the other, the ſand will come out of the holes, becauſe it cannot immediately acquire the quick motion downwards, which is given to the box by the ſtroke. The ſand does not aſcend, properly ſpeaking, but the perforated top of the box is driven below the ſurface of the ſand.

Lay a card upon a glaſs, a halfpenny upon the card, and with your fingers draw the card ſuddenly away, the halfpenny will fall into the glaſs. If you draw the card ſlowly, the halfpenny will be drawn off with the card; but when it is done quickly, the friction between the two being little, on account of the ſmoothneſs of the card, there is not time for the motion of the card to be communicated to the halfpenny, before it is drawn from under it.

The following experiments, founded on the communication of motion, excite conſiderable aſtoniſhment in thoſe, who do not underſtand them.

Set a wine-glaſs on the table, or, if you would ſpare your glaſſes, ſplit a card a little way, and ſet it upright, ſo that it may be thrown down eaſily. Suſpend a tobacco-pipe in ſuch a manner, that it's lower end may hang near the upper edge of the card. Now, if you ſtrike the tobacco-pipe gently toward the card, it will remain whole, and the card will be thrown down: if you give it a ſmart ſtroke in this direction, the pipe *will be broken,* and the card remain erect. *On the* contrary, if you ſtrike the pip *gently from* the card, the pipe will rem

whole, and the card ſtanding: if you ſtrike it ſmartly in this direction, the pipe will be broken, and the card thrown down. This is not difficult to explain. When the ſtroke is ſmart, the motion cannot be communicated with ſufficient quickneſs throughout the whole of the pipe, which, being brittle, breaks at the place where the ſtroke was given, each half turns round it's centre of gravity, and in conſequence the lower end of the pipe, as well as the upper, will move in a direction contrary to the ſtroke.

Draw a hair through the ſtem of a tobacco-pipe, and faſten it horizontally at both ends, you may break the pipe ſtem in two by a ſmart ſtroke, without breaking the hair. The ſucceſs of this experiment depends upon the ſkilfulneſs with which you make your ſtroke: this muſt be ſmart, and ſhort, without letting the inſtrument, with which you ſtrike, deſcend too low. The pipe breaks for the reaſon mentioned in the preceding paragraph; the hair remains whole on account of it's elaſticity.

Hold a quarter of a ſheet of paper between your finger and thumb, ſo that it may hang freely. If you puſh it, or ſtrike gently againſt it, with a nail, the points of a

of compaſſes, or the like, it will give way and you cannot pierce it; but if you ſtrike it ſmartly with either of theſe, you will make a hole through it.

You can eaſily ſhut an open door by puſhing it, but if you give it a violent ſtroke with your fiſt, you will ſhake it only, not ſhut it. If you would ſhut a door with violence, you muſt take hold of it with your hand, and exert the power of the arm upon it by a motion gradually accelerated.

A moderate blow with a ſtick againſt a pane of glaſs will break it into ſeveral pieces; but a ball fired out of a muſket will make a ſimple round hole in it; while the ſame ball, thrown with no great force, would break it to ſhivers.

To one arm of a balance ſuſpend a weight by a long thread, and hang at the other arm a weight ſufficient to counterpoiſe it. If, while you prevent the arm from riſing by keeping your hand or finger on it, you raiſe the ſuſpended weight a little way, and then let it fall, the thread will remain whole, and the other end of the beam will be raiſed. If you let the weight fall from a conſiderable height, the thread will ſnap, and the balance remain unmoved. If you ſuſpend two weigh

by a thread paffing over a pulley, fimilar confequences will take place.

Pliny relates, that near the town of Harpafa, in Afia Minor, is a very large rock, which you can move with a fingle finger, while it obftinately refifts a fturdy ftroke. In this there is certainly nothing improbable, though it appears ftrange; for we may fuppofe the ftone to reft on it's bafis in the manner of a four-legged table, which has one leg too fhort; and this we know might be moved by the preffure of a finger, though a blow with a hammer would not ftir it. The *logging-ftones*, or rocking-ftones, which ftill exift in different parts of our own ifland, are curious remains of antiquity of a fimilar kind, being ftones of confiderable bulk and weight, fo nicely poifed on a flender bafe, that a flight effort is fufficient to move them; though it would require a very great power to throw them down, from the fhifting of their centre of gravity, in confequence of the change in the point on which they bear.

CHAP. LIII.

SUPPLEMENT TO THE FIRST CHAPTER.

WILLIAM wanted to pour back a glas[illegible] [illegible] the decanter, and fet abou[illegible]

very cautiously and slowly, that he might not spill any. The slower he poured, however, the worse he succeeded, the wine running down the side of the glass.

"Pour briskly," said his sister, who was a little older, and more experienced in such things, "or you will spill it all."

William took her advice, and was more successful.

"Do you perceive the reason of this?" said his father.

William. "Not very clearly. I rather feel it, than understand it."

Father. "So it is with many things in common life. Experience gives those, who do not trouble themselves about causes, a foreknowledge of effects to a certain degree. Every alehouse-keeper knows, that he must pour briskly out of his full mug, to fill the glass without spilling the liquor, though he is unacquainted with the theory of it. Every journeyman mason knows where he must lay hold of his crow to move a stone, though he is ignorant of the laws of the lever. The billiard-player can tell how he *must strike* his ball to hole his adversary's, *though* he has never studied the laws of *percussion* of elastic bodies. The waggon

is able to judge, whether his horses be equal to the task of drawing a loaded waggon up a hill, though he has never heard of the theory of inclined planes. He must be very short-sighted, however, who hence concludes, that science is unnecessary.

"The attraction that takes place between the particles of the liquor and the glass, and between the particles themselves, is the cause of the liquor's running down the side of the glass. The first drop, which, were it acted upon by the power of gravitation alone, would fall perpendicularly from the brim of the glass, is detained by the attraction between the particles of the liquor, hangs a little over the brim of the glass, touches it's external surface, is attracted by this, and slides down it, because it's weight is too little to overcome this attraction. Each succeeding drop is drawn along by this, and in like manner runs down the side of the glass."

W. "How is it, then, that it runs down the side of the glass only at first, when the glass is pretty full, and goes into the decanter very well, when the glass is half empty?"

F. "When you pour out of a full gla[illegible] he side of the glass is inclined in a very ac[illegible]

angle to the perpendicular, through which the drop would fall; of courſe it is very near to the drop, that is about to fall, and therefore it's attraction for it is conſiderable. When the glaſs is in part emptied, you muſt incline it more, to pour the liquor out, ſo that the ſide is carried farther from the drop, and conſequently attracts it with leſs force."

W. "Now I underſtand it clearly, and perceive the reaſon, why pouring the liquor out briſkly prevents it from running down the ſide. By doing this a quicker motion is given to the liquor, ſufficient to overcome the attraction between it and the glaſs at firſt; and at the ſame time the glaſs is ſooner brought to a greater inclination, and thus carried farther from the ſtream."

F. "You now know the reaſon why ſome veſſels are made with a projecting brim all round, others with a projection at one part only, which we call a lip.

"Liquor may be prevented from running down the ſide of a veſſel too, by ſmearing the outſide, at the place where you intend to *pour it out*, with any thing, to which the *liquor will* not eaſily adhere, as greaſe, *the ſeed of* clubmoſs.

fide of a glafs, becaufe it's particles have little attraction to the glafs, more to each other, and confiderable weight.

"If you would have a proof of the adhefion, that takes place between water and many other things, bring me a pair of fcales, a bowl of water, and a trencher."

William having brought thefe, the trencher was fufpended horizontally beneath one of the fcales, and balanced by putting weights into the other. The fcales were then held in fuch a manner, that the bottom of the trencher juft touched the furface of the water in the bowl, without finking into it. The other fcale then bore an ounce more, without raifing the trencher; but on adding ftill more weight, the trencher was raifed fuddenly, fo that it was evident, the water had held it down.

With one more experiment we fhall conclude. Lay a bit of cork on the furface of fome water in a wine-glafs, and fee whether it will ftay in the middle. You will find, that it will always fwim to the fide of the glafs, and the fafter, the nearer it is to it. When it touches the fide, it will be raifed up a little likewife. Replace it in the middle as often as you will, it will ftill remain to the fide.

END OF VOL. I.